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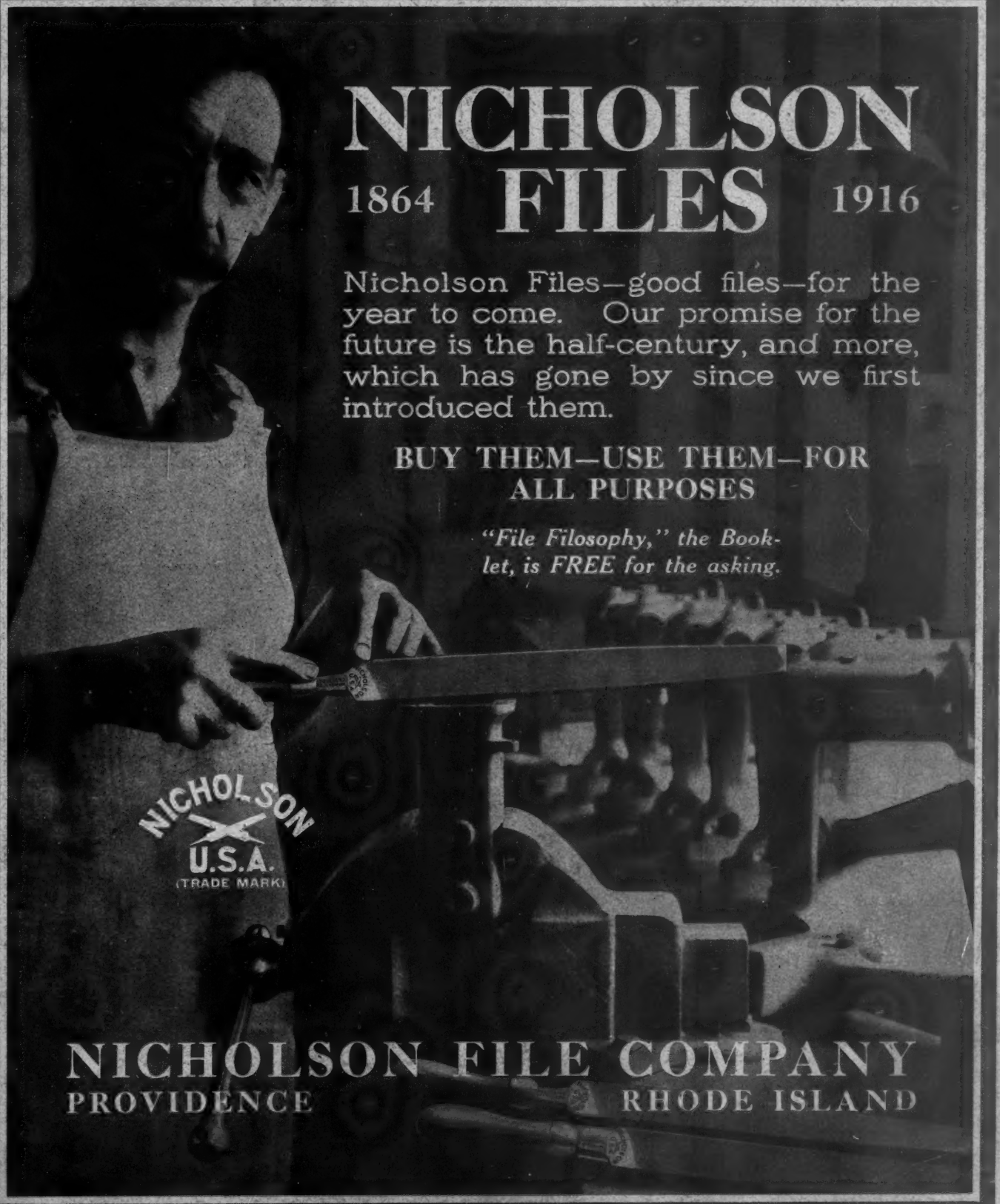

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JANUARY MACHINERY 1916

The Production of Die-Pressed Castings

Edward K Hammond

Until recently, the production of many machine parts was limited practically to one of two methods—either turning the pieces from bar stock or casting them in sand molds. The disadvantage of the former method lies in the large proportion of the material that is converted into scrap; and it is well known that the castings produced in sand molds are likely to be defective from several causes. These objectionable features have been overcome by the development of a method for making "die-pressed" castings which can be brought extremely close to the required dimensions of the part, with a smooth surface and uniform structure of the metal. Such defects as blow-holes, pin-holes, etc., which occur in ordinary castings, are not found in die-pressed castings. The method is applicable for use in producing a great variety of parts, and that it may be successfully applied on a commercial scale is attested by the fact that thousands of different parts are being produced by it in the leading manufacturing countries of Europe. Brass, bronze, copper, aluminum, nickel and other metals lend themselves to this treatment.

WHILE the production of die-pressed castings has only become of importance in this country since the outbreak of the European war, this process of improving the quality of soft metal castings has been used in Germany for some years in making a great variety of parts. An idea of the range of work for which this method of manufacture is adapted will be obtained from the fact that the Allgemeine Elektricitäts Gesellschaft, Berlin, Germany, is producing over 5000 different parts in this way. The term "die-pressed casting" is used to denote a part which is made by pressing the metal to the required shape in a suitable die, and the pieces which can be produced vary greatly in shape and size. Parts with long extensions or undercuts may be made with satisfactory results, and there are several metals which lend themselves to this method of treatment.

Die-pressed castings are used as a substitute for ordinary castings, over which they possess several noteworthy advantages. The finish obtained is equal to that secured on die-castings, and in many cases no subsequent machining operation is required; but where a very fine finish is necessary die-pressed castings have a further advantage over ordinary castings in that they are of absolutely uniform size and give no trouble when a magazine attachment is employed to feed them to a chucking lathe for performing the finishing operation. Another important feature is that there is no hard outer skin, as in the case of ordinary castings, and as a result, the life of the cutting tools is considerably increased.

The high pressure under which die-pressed castings are formed results in the production of a very dense metal, the tensile strength of which has been increased about 15 per cent by the mechanical treatment; and all such defects as blow-holes, pin-holes, and other imperfections found in ordinary castings are eliminated. An idea of the magnitude of the refining action which takes place will be gathered from the photomicrographs of the metal before and after being pressed in the die, which are reproduced in Figs. 3 and 4. These show a magnification of fifty-five diameters. In many cases the cost of producing die-pressed castings is lower than the cost of making ordinary castings, and the method is much cleaner. The metal is generally worked hot, but it is sometimes feasible to perform the pressing operation on cold metal, the shape of the parts to be formed and the metal from which they are to be made being the governing factors. The selection of a suitable metal for the work is extremely important, and the manufacturer who considers the employment of this method for making his castings will do well to give this matter careful consideration. Die-pressed castings of brass, bronze, copper, aluminum, nickel and other metals are now being produced in this country with satisfactory results. In making brass parts, an alloy of 54 per cent copper, 44 per cent zinc, and 2 per cent lead will be found to give satisfactory results.

The dies used are of two general types. Where possible, the metal is entirely confined in the die, and in such cases the part produced has a uniform surface without any fin. For certain classes of work, however, it is necessary to employ dies of the type used in making drop-forgings, and parts pro-

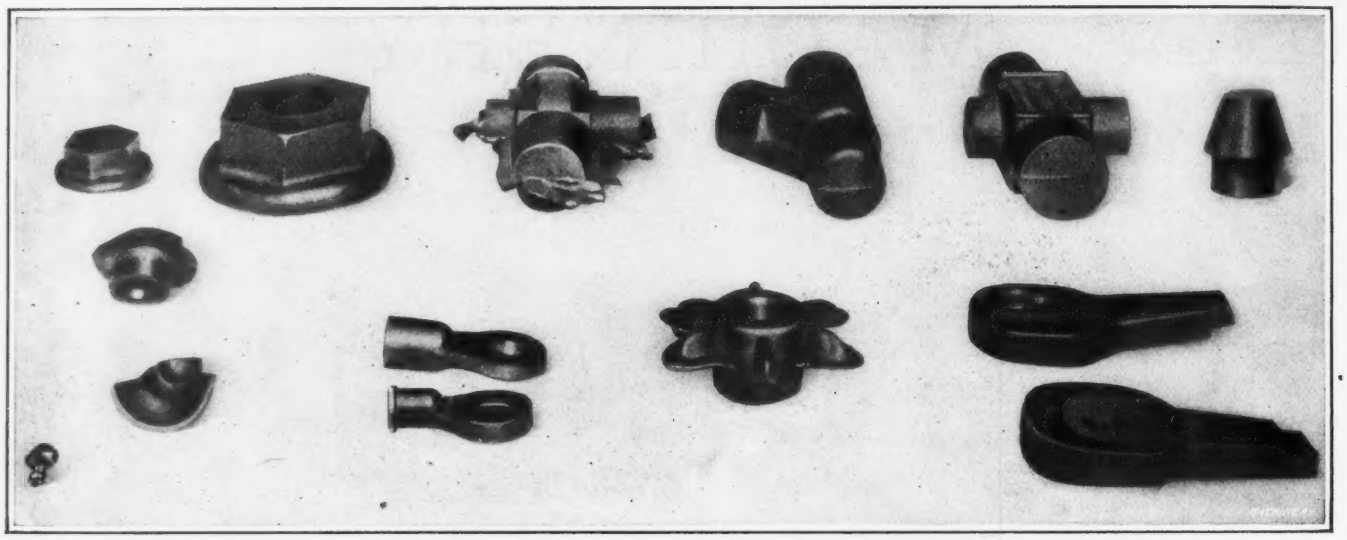

Fig. 1. Die-pressed Castings for Use on Oxy-acetylene Welding Equipments, Phonographs, Electrical Apparatus, Watches, etc.

duced in dies of this kind have a fin around the entire periphery which must be removed by a subsequent operation. In both of these types of dies, but more especially in the type where the metal is completely confined, the pressure is extremely high. The condition produced is essentially one of hydrostatic pressure, and the dies must be carefully designed to withstand this pressure according to the established practice followed in designing high-pressure hydraulic cylinders.

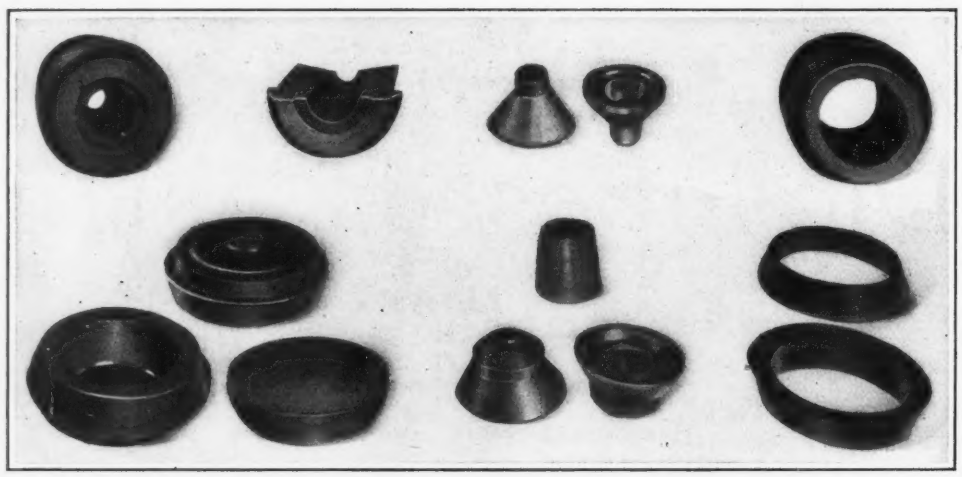

Fig. 2. Examples of Die-pressed Castings for Fuse Parts and Similar Pieces—note High Quality of Finish that is obtained

Suggestions in Regard to the Design of the Dies

After gaining some experience in the manufacture of die-pressed castings, the designer will be able to form an accurate opinion as to the pressure capacity of the press required to produce a given part. In determining the unit pressure which the die will be called upon to resist, he will divide the number of pounds which represents the pressure capacity of the press by the number of square inches in the cross-sectional area of the space in the die on a plane at right angles to the line of travel of the ram. This will give the pressure per square inch which will be set up in the die, and as it is known that hydrostatic pressure acts uniformly against the retaining walls in all directions, it will be an easy matter to determine the total pressure on the walls of the die.

The foregoing will probably be better understood by following through the steps in an actual example. Suppose the size of the die-pressed casting and the metal from which it is to be produced are such that a press developing 100,000 pounds is required, and that the cross-sectional area on a line at right angles to the line of travel of the ram is 2 square inches. The unit pressure set up in the die in pressing this part will then be:

$$\frac{100{,}000}{2} = 50{,}000 \text{ pounds per square inch.}$$

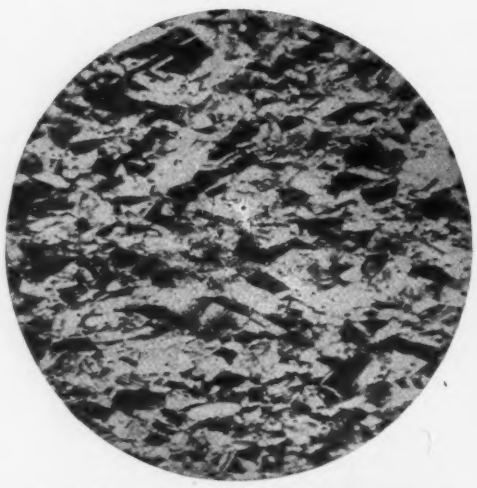

Fig. 3. Photomicrograph of Brass Surface before being subjected to Pressing Operation—note Coarse Structure of Metal. Magnification, 55 Diameters

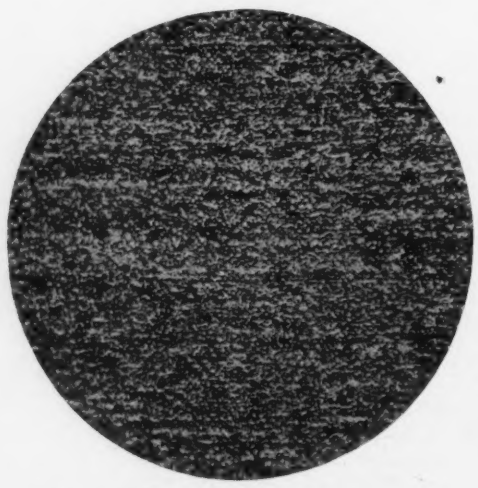

Fig. 4. Photomicrograph of Same Brass after being subjected to Pressing Operation—note Improvement in Metal Structure. Magnification, 55 Diameters

Assuming that the total surface area of the die-pressed casting to be produced is 3 square inches, the total pressure imposed upon the walls of the die will be:

$3 \times 50{,}000$ pounds $= 150{,}000$ pounds.

The walls of the die will then be made of the necessary thickness to safely withstand this

pressure, the design being worked out according to standard practice in the design of high-pressure cylinders.

In addition to the two general classes of dies referred to, there is a third class which is really a special case of the type of die in which the metal is completely enclosed. These dies are made in halves in order that they may be parted to remove the work in a manner similar to that in which an ordinary sand mold is opened to take out the pattern. Parts which are of such a shape that they could not be removed from solid dies can be made in split dies of this type. It will be evident that any ordinary clamping device for holding the halves of such dies together would be entirely inadequate to withstand pressures up to 150,000 pounds per square inch which are sometimes developed in these dies. The method employed consists of making the outside of the die so that it will fit into a tapered shoe possessing ample strength for holding the halves of the die rigidly in place. When this practice is followed, it is customary to have the knock-out on the press arranged so that it will lift the two parts of the die out of the shoe on the up-stroke. As the ram rises, the operator removes the work with a pair of tongs and puts a fresh blank in place in the die. The two parts of the die are then released and allowed to drop back into place in the shoe ready for the next operation. Although the description may make the tool appear rather complicated, the die may be operated quite rapidly.

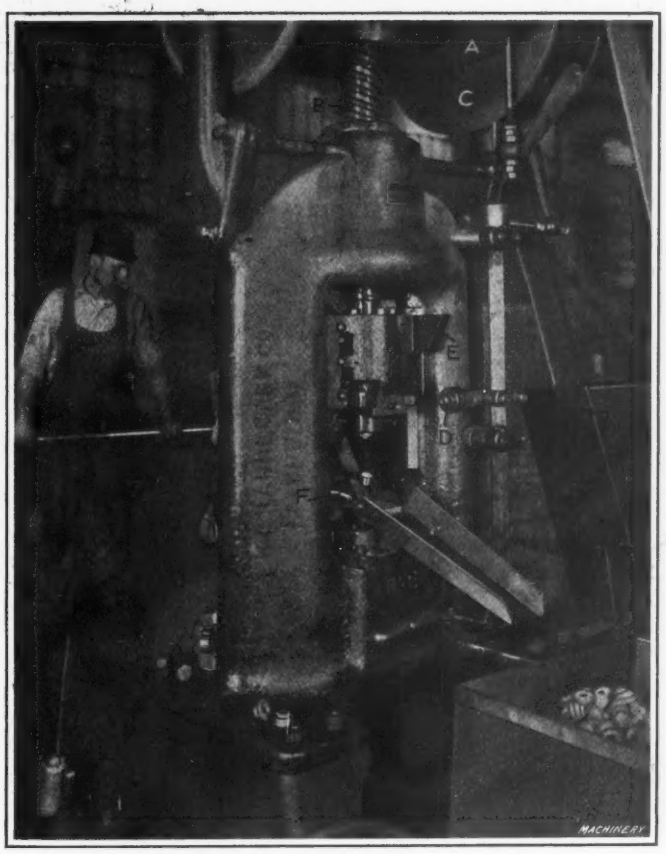

Fig. 5. Zeh & Hahnemann Percussion Press used for making Noses for Shrapnel Shells—note Compressed Air Nozzle F which blows Finished Castings into Chute

It has been stated that in making die-pressed castings of brass, the slugs of metal are heated to a forging temperature preparatory to pressing them into shape; and it will be evident that this temperature would result in drawing the temper of ordinary tool steel. As a matter of fact, the continual operation of the dies on hot metal results in raising their temperature to a red heat; consequently, the steel used for making the dies must be of a type which possesses the property of red-hardness. To prevent danger of damaging the dies through overheating, each of the presses is equipped with a nozzle which delivers a blast of air onto the die at each upstroke of the press, to keep the temperature of the die down as far as possible, and this air blast serves the further purpose of blowing all scale and other foreign matter off the die.

Tungsten steel is the material best adapted to the requirements of making dies for pressing hot metal, but owing to its high price at the present time, it would be extremely costly to make the dies entirely from this material. As a result, the expedient has been adopted of making the inner part of the die of tungsten steel and shrinking one or more machine steel collars around it to give the required strength. This practice is similar to that followed in the construction of heavy artillery, and in addition to effecting a saving in the cost of material, it also affords ample strength, because the application of pressure results in first reducing the tensile stress in the die to zero before any stress is introduced in the die as a result of the pressure set up while pressing the work to the required form.

In starting to design a pair of dies for use in the manufacture of parts where the metal must be worked hot, allowance must be made for the fact that the pressing operation is performed on the metal at a red heat, so that it will shrink considerably while cooling. As a result, the dies must be made over size in order that the work will shrink to the required size when cold. For example, the fact has been established that the coefficient of contraction of brass is 0.00000957 inch per inch per degree F., and in cooling, the temperature of the metal will be reduced from 1500 degrees F. to approximately 70 degrees F.; hence we find that the following allowance per inch must be made in determining the required size of the dies:

$(1500 - 70) \times 0.00000957 = 0.014$ inch.

The tendency of the work to shrink while cooling has another important effect upon the

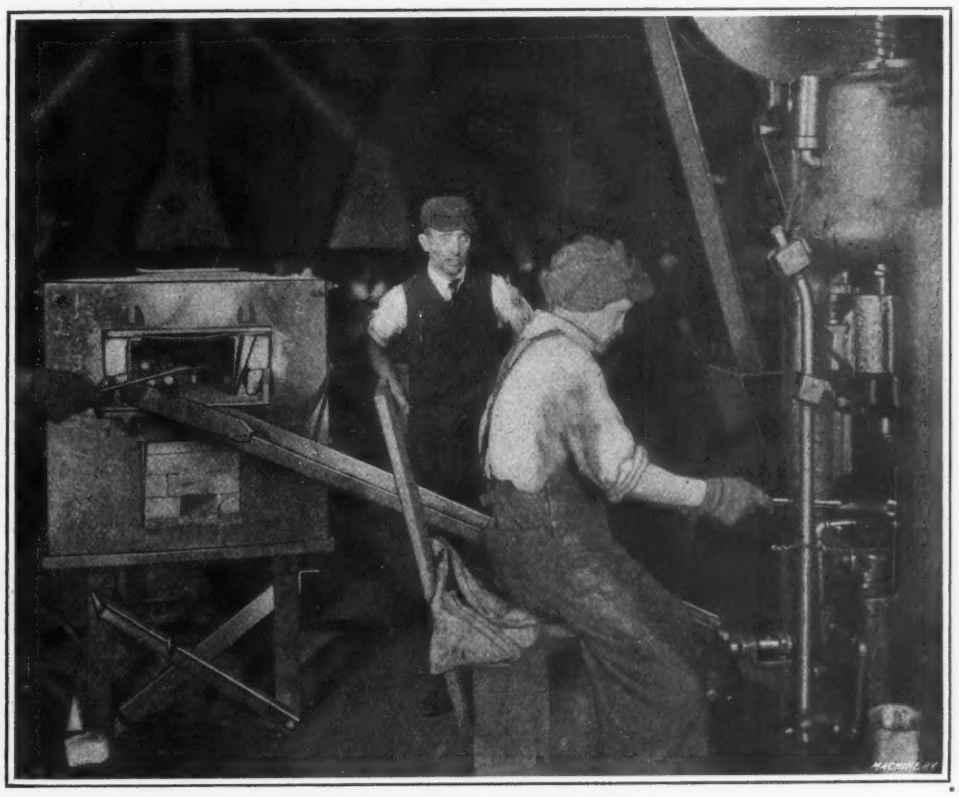

Fig. 6. Opposite Side of Zeh & Hahnemann Press shown in Fig. 5—note Arrangement of Chute for carrying Blanks from Heating Furnace to Press

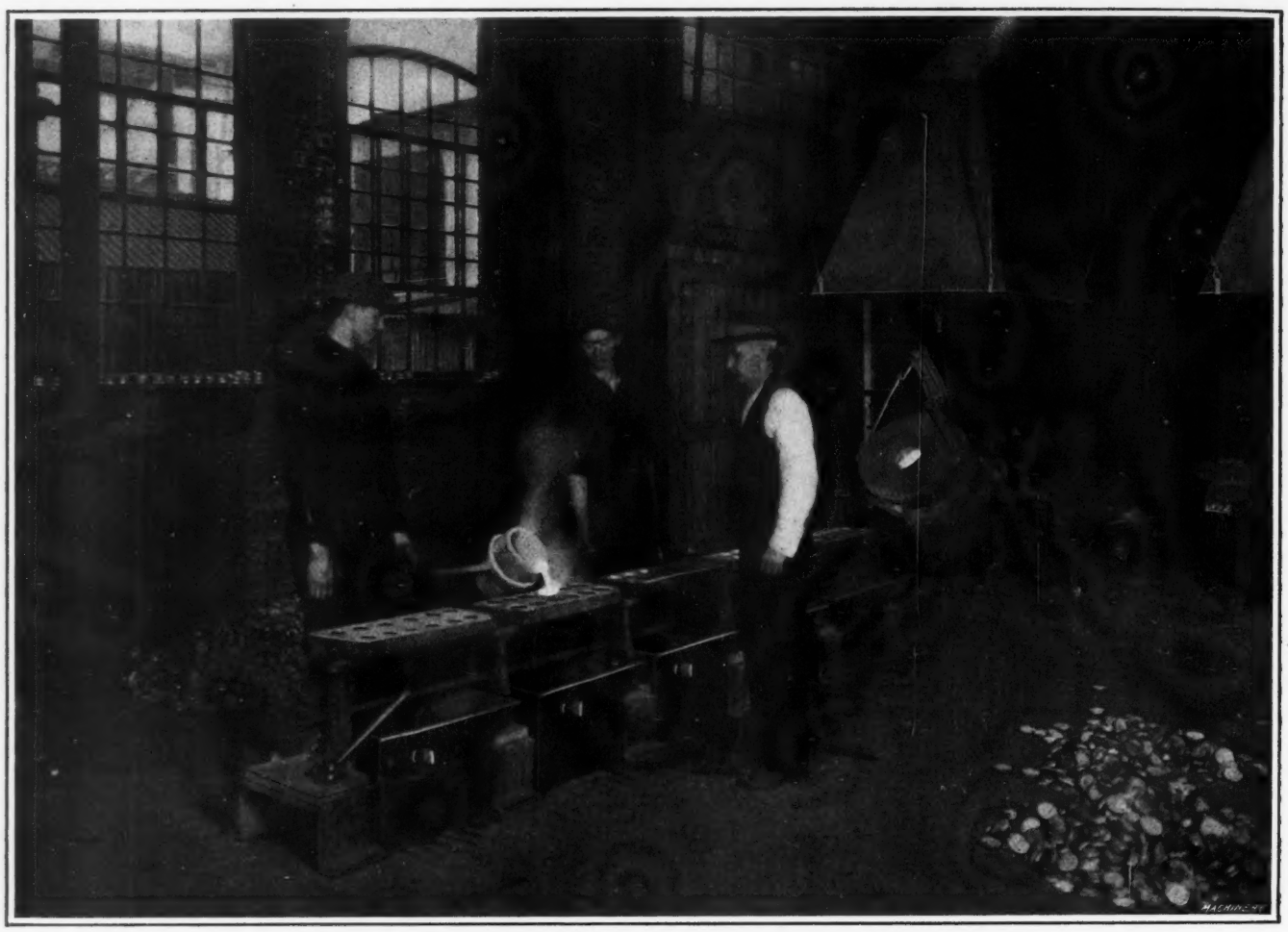

Fig. 7. Melting Furnaces and Metal Molds used for casting Blanks

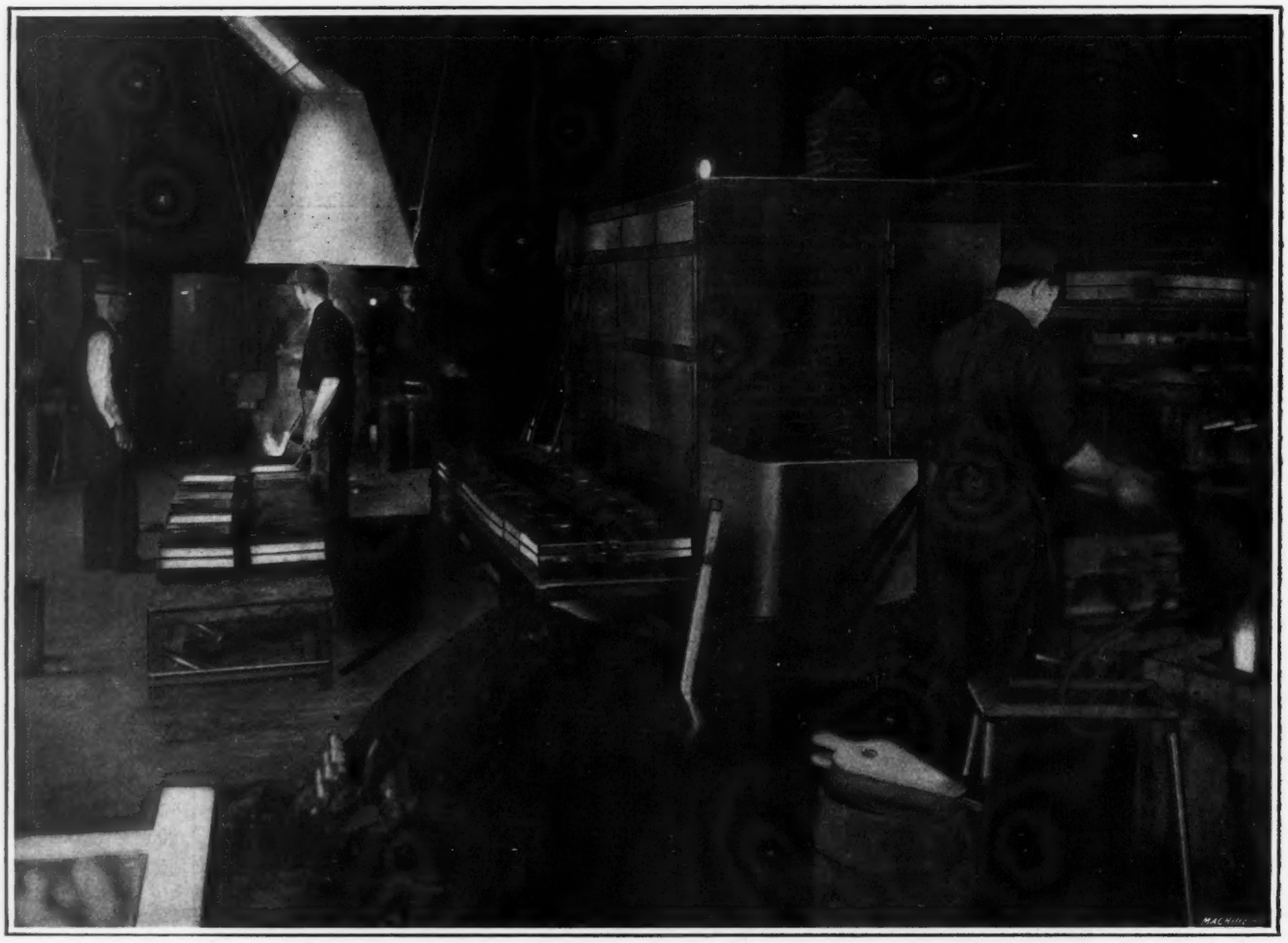

Fig. 8. Molding Bench, Sand Molds and Melting Furnace for producing Blanks

Fig. 9. Loading Side of Continuous Milling Fixture used for facing Blanks cast in Molds shown in Fig. 7

practice followed in the design of dies. When the work is of such a form that a hole or socket is formed by a pilot in the die, the shrinkage of the metal in cooling may cause it to bind so tightly on the pilot that its removal will be an extremely difficult matter. To avoid trouble from this source, such pilots must be tapered to facilitate the removal of the work, and experience has shown that the amount of taper necessary varies from 4 to 8 degrees according to the size of the work and the metal from which it is made. The dies are usually provided with automatic ejectors for removing the finished parts. The dies must be lubricated while in action, and experience has shown that a mixture of oil and flake mica is one of the most satisfactory lubricants which can be employed. When this mixture is applied to the hot die there is sometimes a tendency for the oil to "flash," but in such cases the mica still remains and provides a very satisfactory lubricating action.

Type of Power Press Used for Applying Pressure to Dies

In the manufacture of die-pressed castings, there are several reasons which make the friction-screw or so-called "percussion" type of power press well suited to the requirements of this industry. The most important of these is the fact that it is practically impossible to avoid slight variations in the volume of the slugs of metal from which the die-pressed castings are made. It will be evident that the presence of an excess of metal in the die will result in a tendency for the press to be stalled, but trouble from this source is eliminated in two ways: first, the driving member on the machine does not pass over a dead-center, and so the drive is continuous without any one point at which there is a particular tendency for the machine to stall; second, in the event of the excess of metal in the dies being so great that the machine cannot complete its stroke, the drive will reverse automatically without danger of damage to the tools or to the machine. Conversely, if the slug placed in the die contains too small a volume of metal there will be a slight over-travel of the ram, the reversal taking place when the maximum rated pressure of the blow has been applied to the work. As a result such parts will receive the required amount of pressure to obtain the desired compression of the metal.

To explain the reasons for the peculiar adaptability of the percussion press to the manufacture of die-pressed castings, it will be necessary to refer briefly to the method of operation of the friction-screw drive. Referring to Fig. 5, which shows one of these presses in operation, it will be seen that there is a friction wheel *A* mounted at the top of screw *B* which actuates the ram, this wheel being driven in opposite directions for the down- and up-strokes of the ram by alternately engaging the disks *C* mounted on each end of the horizontal driving shaft which runs continuously. The driving shaft is free to move laterally through a distance of about 1/32 inch in either direction, which results in bringing one of the disks *C* into contact with the friction wheel *A* for driving the ram down, after which the shaft is automatically moved over to engage the disk *C* on the opposite side of the wheel *A* to provide for making the return stroke.

The press is tripped by the usual form of foot-lever, and when the ram has reached the bottom of its stroke an automatic trip *D* is engaged by a dog *E* on the ram, which throws over the driving shaft and brings the return disk *C* into engagement with the friction wheel *A*. The ram stops when it reaches the top of its stroke. Presses of this type have been used in Germany for a number of years, but until recently they have not been manufactured in the United States. The Zeh & Hahnemann Co., Ave. A and Vanderpool St., Newark, N. J., specializes in the manufacture of percussion power presses and the tools used for making die-pressed castings. The engineers of this firm have made a careful study of the subject, and we are indebted to them for much of the information presented in this article.

Importance of Performing Pressing Operation at a Suitable Speed

In making die-pressed castings, the speed at which the blow is delivered by the press is an important factor. If the speed at which the blow is delivered is extremely fast, the metal will not have sufficient time to flow into the corners of the die and produce a fully finished casting. In pressing hot metal, if the blow is too slow, the slug will have cooled below a forging temperature before the operation has been completed; as a result, there will be a tendency for the chilled metal to disintegrate instead of taking the form of the die. With the friction-screw or so-called percussion type of press, just the right speed may be obtained, as adjustment may be made to provide a suitable speed for all classes of work. The regulation of the speed is also important because it is required to have the pressing operation extend over a sufficient period of time so that the pressure will be uniformly distributed through the metal and produce a homogeneous structure.

Fig. 10. Opposite Side of Continuous Milling Fixture where Blanks are removed and delivered to Heating Furnace

In connection with the action of the percussion power press, it is of interest to note that the lead of the driving screw does not govern the force of the blow which is delivered by the ram. When the screw has a steep lead, its mechanical driving power is low, but the screw advances the ram at high speed, and so the kinetic energy of the ram is high. By reducing the lead of the screw, the speed of the ram and the value of the kinetic energy are correspondingly reduced, but this loss of power is offset by the fact that the screw of more gradual lead has a greater mechanical driving power. In practice, the presses are designed to take advantage of the maximum mechanical driving power which can be obtained from the screw, and so the lead is made as small as possible, the limiting condition being that point where the inclination of the thread is so gradual that the screw will tend to bind in the nut. The screws are designed to go as close to the sticking point as possible, without actually giving trouble. In the preceding discussion, the kinetic energy is that resulting from the combined mass of the flywheel, screw, ram and upper die moving at the speed of the ram at the time it engages the work.

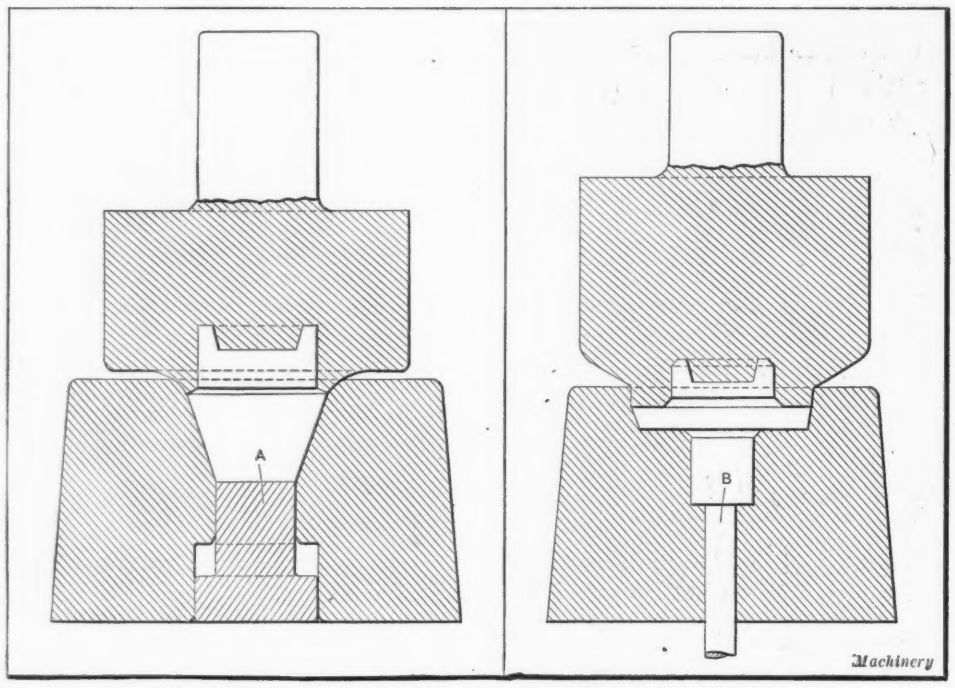

Fig. 11. Two Examples of Dies in which Metal is completely confined

Raw Materials of the Industry

The slugs of metal which form the starting point in manufacturing die-pressed castings that are pressed hot, are heated in oil or gas furnaces preparatory to the performance of the pressing operation. Two operators are required to work each press. One man stands at the back of the machine to remove the slugs from the heating furnace and place them in position in the die. The other stands at the front of the press; and this man operates the machine, lubricates the dies, and removes the finished castings. As the metal is hot, it must be handled with tongs, and so there is practically no danger of the workmen getting their hands caught in the dies.

In the manufacture of die-pressed castings, it is a fundamental principle that the metal should be required to flow through the minimum distance in order to bring it to the required shape of the finished part. There are two ways of applying this principle: first, the dies should always be designed so that the distance through which the metal has to flow is reduced to a minimum; second, the slugs of metal from which the castings are to be pressed may be made of such a shape that the distance through which the metal must flow during the pressing operation will be materially reduced. In the latter case, either of two methods of procedure may be followed. According to one plan, extruded bars of metal are made of a cross-section which approximates that of the finished parts, and slugs containing the required volume of metal are cut off from these bars and subjected to the pressing operation. When it is not possible to use extruded metal, it is often feasible to make castings of approximately the required shape and size, and then subject these castings to a pressing operation. The use of castings made in sand molds is avoided as far as possible, as they are covered with scale and foreign matter which has a deleterious effect upon the dies. The best results are obtained when the slugs are cut off from bars of metal which are produced either by cold-drawing or by the extrusion process.

Description of a Shop Equipped for Making Die-pressed Castings

One field in which the method of making die-pressed castings has recently found wide application is the manufacture of the fuses used on shrapnel and high-explosive shells; and the following description of the practice of a well-known American manufacturing company will give an idea of the manner in which the work is carried on and the rate of production that it is possible to attain. This concern is following the practice of casting blanks containing the required volume of metal and then pressing them into shape. The metal is melted in three 400-pound "Monarch" gas furnaces

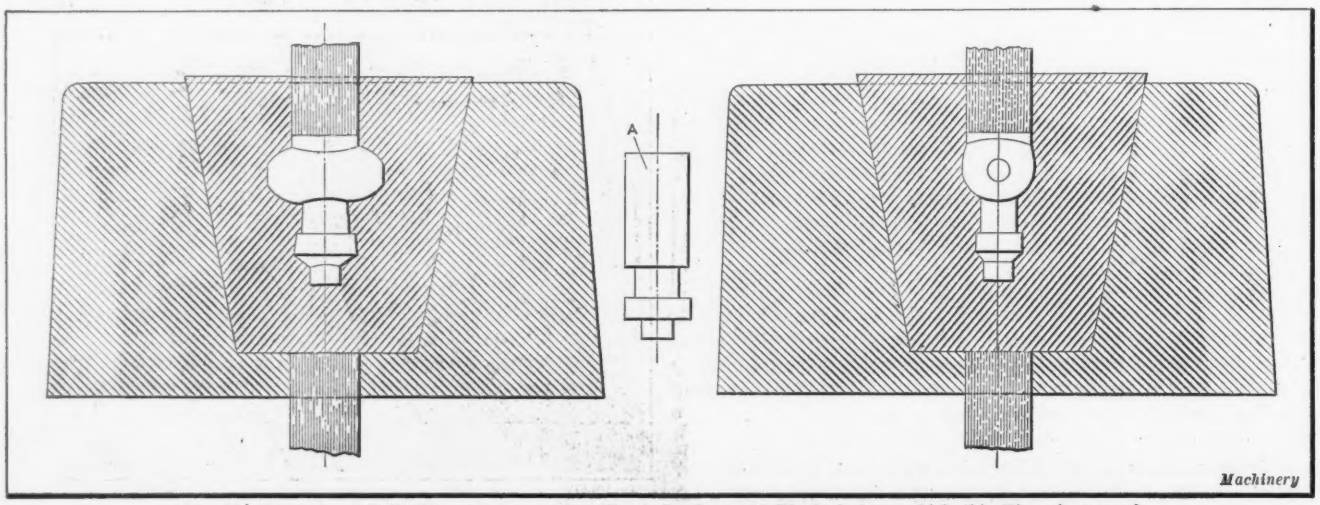

Fig. 12. Example of Split Die used for making Watch Pendant and Blank A from which this Piece is pressed

which use gas at a pressure of 8 ounces per square inch and air at a pressure of 10½ ounces per square inch. One furnace is provided as a reserve, and is used while repairs are being made on either of the other two furnaces. Two methods of casting are employed. Some of the blanks are cast in sand molds, each mold being made up on a match plate which provides for casting twenty-four blanks. Other blanks are cast in special metal molds of the form shown in Fig. 7, which does away with trouble resulting from the dies being damaged by sand sticking to the castings. Reference to this illustration will make it evident that the molds consist of iron plates, each of which contains twelve impressions. After the metal has been poured into these molds and allowed to cool, the molds are turned over on their pivotal support so that the blanks are dumped out into a receiver after which the molds are ready to receive a fresh lot of metal.

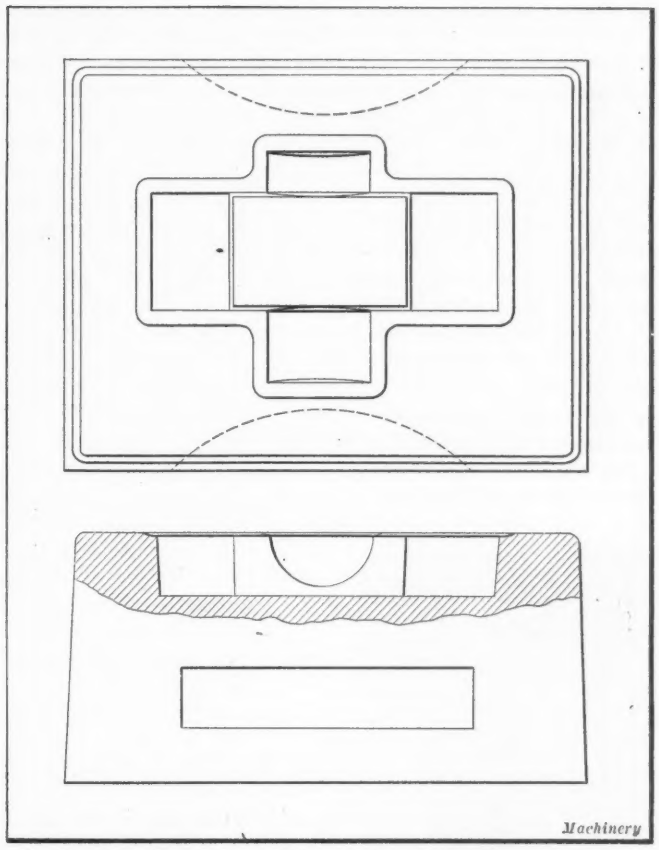

Fig. 13. "Drop-forge" Type of Die used for making Die-pressed Castings

The only treatment given to blanks cast in the metal molds, before they are subjected to the pressing operation, consists of facing off their top surface, for which operation a No. 4 Brown & Sharpe milling machine, equipped with a continuous milling fixture, is employed. The machine and fixture used for this operation are shown in Figs. 9 and 10, where it will be seen that the fixture consists of a large disk with collet chucks arranged around the periphery. Two operators are employed; the man at one side of the machine loads the rough blanks into the collets as they come around and tightens up the nut at the back of each collet, which secures the work in place. As the fixture revolves, the blanks are fed over a milling cutter which faces them off, and continued rotation of the fixture brings the faced disks around to the second operator who removes them.

The faced blanks are next taken to the heating furnace in which they are brought to a temperature of approximately 1500 degrees F. preparatory to pressing them to shape. The furnaces used for heating the blanks were especially constructed for the purpose; they are heated by gas and have a door at both front and back. One furnace is provided to heat the blanks for each of the presses. The work is introduced through the back door and pushed forward into the body of the furnace, where it is allowed to remain long enough to reach the required temperature. The press operator has a helper stationed at the front door of the furnace, and there is a metal chute leading from the door to the die-bed of the press. The helper reaches into the furnace with an iron hook and draws out one hot blank at a time. The blank is pulled to the top of the chute, down which it runs by gravity to the bed of the percussion press.

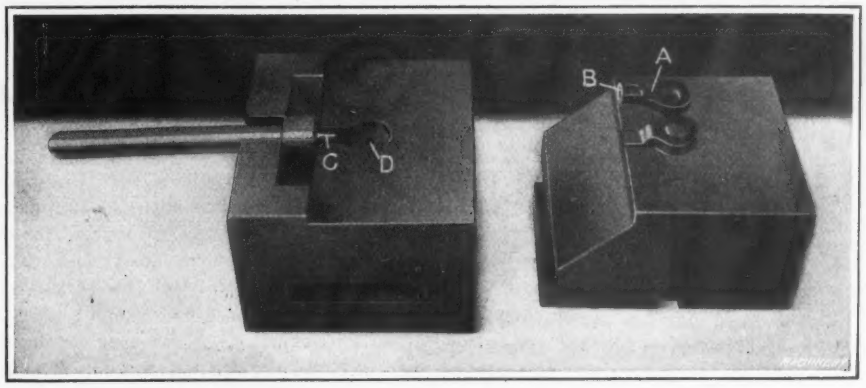

Fig. 14. Pair of Dies used for pressing Electrical Cable End from a Copper Blank. Piece made in Die is shown at A

The arrangement is clearly illustrated in Fig. 6.

The press operator picks up the piece with a pair of tongs, places it in position in the die and trips the press; then the ram descends and presses the part into approximately the desired shape, and as the ram rises a stripper lifts the pressed part out of the die. Just before the ram reaches the top of its stroke, a trip opens the valve of a compressed air nozzle with the result that the finished part is blown off the die into a receiver put in position at the opposite side of the press. The dies are lubricated with mineral lard oil which is applied with a swabber at intervals of twenty operations. In addition to blowing the finished piece off the receiver, the compressed air jet serves the purpose of keeping the die cool and of removing particles of scale dropped from the work.

The method of procedure followed in handling the parts cast in sand molds is essentially the same, except that these parts do not receive any preliminary machining operation. They are broken off the gates and shaken in an ordinary riddle to remove particles of sand which might exert a harmful effect upon the punch and die. The brass blanks in the riddle are then dumped into the back door of the furnace and pushed forward ready to have their temperature raised to 1500 degrees. In both cases the parts produced in this way are brought to within about 1/64 inch of the finished size, and after being pressed into shape they are taken to the machine shop where the finishing operations are performed. The rate of production is about 2500 pieces of each kind from each machine in a ten-hour day, and this surprisingly high output is obtained with an exceptionally small amount of labor. The complete force of men includes four men to look after skimming the dross from the melting pots and pouring the metal, and these men also shake out the sand molds; two men to operate the milling machine; an operator and helper for each of the two percussion power presses; one sand molder; and a foreman in charge of the department.

Examples of Typical Forms of Dies that Illustrate Principles of Design

As a supplement to the information presented in regard to the different types of dies employed in making pressure castings and the data in regard to the design of such dies, the following description of typical dies will doubtless prove of interest. Fig. 11 shows two examples of the type of die in which the metal is completely enclosed; and the construction of these dies will be fairly evident from the illustration without requiring an extended description. About the only thing that need be said is that in each case provision is made for automatically removing the work

from the die by means of ejectors *A* and *B* which are operated by the knock-out on the press.

Fig. 12 shows a case in which it was necessary to split the die in order to provide for removing the work after it has been pressed into shape. The piece to be produced is the pendant (shown in Fig. 1) for an Ingersoll watch, and the material is nickel. The blank from which the piece is pressed is a screw machine product of the form shown at *A*, and it will be evident from the illustration that the long cylindrical portion of this blank extends up into the hole at the top of the die. The punch is a plain cylindrical member which merely applies the necessary pressure to the top of the blank to cause the metal to flow into the die and take the desired form. An interesting feature of this operation is that the work is done cold, and the finish obtained is extremely fine.

Fig. 13 shows an example of the type of die which is of the same general class as the dies employed in making drop-forgings. The particular form of die shown in the illustration is used for making part of an oxy-acetylene welding outfit,

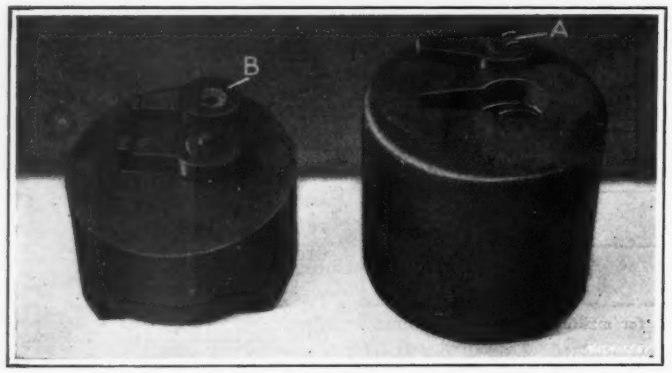

Fig. 15. Pair of Dies used for pressing Phonograph Part. Opposite Sides of the Piece produced are shown at A and B

which is shown in Fig. 1, and the design of the die will be evident from the plan and cross-sectional views of the lower member. The construction of the upper member is essentially the same as that of the lower member shown in the illustration.

The die shown in Fig. 14 is used for making an electrical cable end from copper, and one of the finished parts is shown at *A* in this illustration. The interesting feature of this die is the manner in which the longitudinal hole is formed in the work at *B*. It will be evident from the illustration that this result is obtained by means of the mandrel *C*, but in order to allow the knock-out *D* to eject the work from the die it was necessary to provide means for lifting the mandrel out with the work. This was done by having the mandrel carried on a stem which fits into a slot in the die-block so that it is free to be lifted vertically when the knock-out lifts the work from the die.

Fig. 15 shows the die used for making a phonograph part, and one of the finished parts is shown at *A* and *B* in order to illustrate opposite sides of the piece. The design of the die will be evident from the illustration, but it may be mentioned that there is a knock-out in the lower half of the die which ejects the work on the up-stroke of the press.

The die shown in Fig. 16 is interesting for two reasons. In the first place, this is a case in which a shrink-ring *A* of machine steel is provided to surround the tungsten steel die in order to reduce the cost and still provide sufficient strength to withstand the pressure which is developed. This illustration also affords an example of a case in which the metal is not completely enclosed, and as a result a fin is left on the work which must be removed by a subsequent operation. A clearance space *B* is provided in order to allow the excess metal to escape from the die.

Probable Future Application of Die-pressed Castings in the United States

In order to give an idea of the range of parts that are being produced from die-pressed castings in Germany, the statement was made that the Allgemeine Elektricitäts Gesellschaft is making over 5000 different pieces in this way. These are used chiefly on electrical apparatus, but the application of die-pressed castings is by no means confined to this field. A few examples of die-pressed castings which are at present made in this country are shown in Figs. 1 and 2, and in these illustrations the work ranges in size from a small watch pendant up to the bodies of shell fuses.

The discussion of the production of die-pressed castings which we have presented has been restricted to the methods employed in making these parts under a power press; but the possibilities extend beyond the range of such machines. In making certain large parts from brass and bronze, it is found desirable to work the metal cold, and in such cases the dies are operated by a hydraulic press of suitable capacity. The speed at which the operation is conducted by a hydraulic press would be too slow for working hot metal, but in the case of cold metal, the only limitation imposed by the speed of operation is in so far as it affects the cost of production. Examples of large brass and bronze parts pressed from cold metal are shown in the heading illustration.

Another interesting application of the method of producing die-pressed castings is in the case of nests of small gears and other parts, where the positions of the individual members of a group are required to bear a definite relation to each other. Die-pressed castings of this kind are used in place of parts which are made separately and then assembled together, and the chief advantage of the new method of manufacture is that it eliminates the labor cost of assembling. An idea of the work that can be done along this line will be obtained from the fact that one manufacturer is producing these nests of small gears from steel. The material used is machine steel and the blanks are pressed to the desired form in dies operated in a hydraulic press; no subsequent finishing is necessary. The metal is worked cold to avoid damage of the work from oxidation.

The manufacture of die-pressed castings is a comparatively new art in this country, so that any forecast as to the possible applications of the method is purely a matter of conjecture. But the gratifying results which have been obtained by those manufacturers who have taken up the work, coupled with the

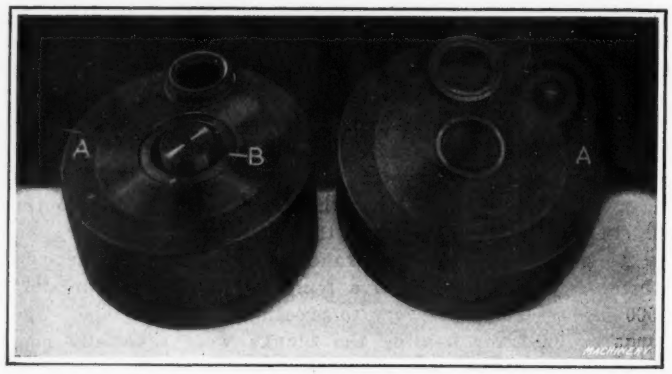

Fig. 16. Example of Die on which Shrink Ring A is employed to give Additional Strength—note Clearance Space B for Excess Metal which forms Fin on Work

fact that a great variety of parts are being successfully produced abroad, justifies the statement that the industry is one that is destined to fill an important place in the list of American manufactures.

* * *

A great deal has been said about the South American market in broad generalizations and, no doubt, with much exaggeration, for after all, the South American market cannot amount to so very much for many years to come. On the other hand, very little is being said about the Russian market, although Russia, with a population of 170,000,000 people and enormous natural resources, forms a much larger, and probably also a more desirable, market for American exporters. Of the total imports of Russia during 1912, amounting to nearly $600,000,000, more than 45 per cent were supplied by Germany, 12 per cent by Great Britain and only 7½ per cent by the United States. There is a great future for the machine industry in Russia, and after the war there will be a considerable demand for all classes of machinery.

HISTORY OF MACHINE TOOLS*

A REVIEW OF THE EARLY DEVELOPMENT OF MACHINE TOOLS IN ENGLAND AND THE UNITED STATES

BY JOSEPH W. ROE††

THE development of simple tools into complex structures to replace manual labor is comparatively recent, and may be considered as having begun near the end of the eighteenth century. The history of civilization since that time has been so profoundly affected by the work of the engineer and the mechanic that the past and the present century may well be called the "age of machinery." Every student of economics and history recognizes the influence of the steam engine, the steamship, the locomotive, and the great textile inventions on modern life, but few outside of the mechanical field know that these inventions could hardly have been conceived, and, if conceived, could not have been realized, until machines were developed with which to build machinery; hence, the development of machine tools is the basis of the development of all other classes of machinery and of modern inventions generally.

The facilities for cutting metal in 1780 were little better than those of the Middle Ages. The mechanics or millwrights of that day worked almost wholly with the hammer, chisel, and file. Without doubt, the best mechanics during the eighteenth century were the French, and their work contained suggestions of a number of the modern machine tools; but their tendency was toward refined handicraft and ingenious novelties, and they showed little aptitude for commercial production on a large scale. The real development of the modern machine tool has taken place almost wholly in England and in the United States. The general machine tools, such as the lathe, planer, shaper, drill press, and steam hammer, and the small tools, such as taps and dies, were developed in England from about 1800 to 1850. In America, partially overlapping this period, but in the main in the latter part of the nineteenth century, were developed the automatic lathe, the universal milling machine, drop-hammers, special machine tools of all kinds, and the interchangeable system of manufacture, the last involving the use of jigs, fixtures, and limit gages.

Early British Boring Machines

The first "modern" tool was a boring machine built by John Wilkinson in 1775. Smeaton had built one in 1769 which had a large rotary head, with inserted cutters, carried on the end of a light, overhanging shaft. The cylinder to be bored was fed forward against the cutter on a rude carriage, running on a track laid in the floor. The cutter-head followed the inaccuracies of the bore, doing little more than to smooth out local roughness of the surface. Watt's first steam cylinders were bored on this machine and he complained that one, 18 inches in diameter, was 3/8 inch out of true. Wilkinson thought of the expedient, which had escaped both Smeaton and Watt, of extending the boring-bar completely through the cylinder and giving it an outboard bearing, at the same time making it very much larger and stiffer. With this machine, as shown in Fig. 1, cylinders 57 inches in diameter were bored within 1/16 inch of true. Its importance can hardly be overestimated, as it insured the commercial success of Watt's steam engine, which up to that time had not passed the experimental stage.

Development of the Slide-rest

The real foundation for modern tools was laid about twenty years later in the development of the slide-rest. The best lathes then in existence were substantially like the present patternmakers' speed lathe, having wooden ways or shears, a light headstock and tailstock, and an adjustable rest for a hand tool which was used for metal as well as for wood. To Henry Maudslay, of London, belongs the credit for the development of the slide-rest. About 1800, Maudslay combined with this the lead-screw and change-gears, and from then onward the development of the modern machine tools is continuous and rapid. This combination is distinctly Maudslay's, and deserves to be classed as one of the greatest inventions of history. In the South Kensington Museum (London) are three lathes which show how rapidly the idea developed. The first is an old wooden "pole" lathe, with two dead centers set in wooden blocks. A string or strap passed from a foot-treadle below, around the piece to be turned, and up to a wooden spring-pole attached to the ceiling. By working the treadle the piece was rotated alternately backward and forward, the cut being made with a hand tool during the forward movement. This lathe was built in 1800 and fairly represents the state of the art at that time. The second is one of Maudslay's first screw-cutting lathes. It has two triangular bars for a bed, cast-iron headstocks and tailstocks, and a lower spindle in the headstock between the bars connected to the live spindle by a single pair of gears. This lower spindle carried on the end toward the slide-rest a forked clutch into which was fitted a lead-screw of the desired pitch, which controlled the longitudinal movement of the tool. When a screw of another pitch was desired, the lead-screw was changed for one of the required pitch. This machine was built about 1797. The third machine, built in 1800, is distinctly modern. It has a well designed cast-iron bed, a single lead-screw with thirty threads to the inch, change-gears, and a strong, well built carriage with a back-rest to prevent springing of the work. There were twenty-eight change-gears with teeth varying in number from fifteen to fifty. With this machine are exhibited sample screws, about 2 feet long, which were cut on it, having threads varying from sixteen to one hundred per inch.

Maudslay's Influence on Machine Tool Developments

Shortly before his death in 1831, Maudslay built a lathe having a faceplate 9 feet in diameter, capable of turning flywheels 20 feet in diameter and boring steam cylinders up to 10 feet in diameter. This would be a good-sized machine even today, and shows how rapid was the development of the lathe within the lifetime of a single man. Maudslay built the machinery installed in the Portsmouth (England) navy yard during the years 1801 to 1807 for the manufacture of wooden pulley blocks for the British navy. This plant consisted of forty-four machines, constituting a complete range of special tools, each performing its part in a definite series of operations. The general scheme of the substitution of special machinery for the labor of skilled workmen was originated by Sir Samuel Bentham, and the design of the machines by Sir Marc Isembard Brunel. It was the first large order Maudslay undertook, and credit for the excellence of detail and workmanship in the Portsmouth machinery was largely due to him. It established his reputation and was the beginning of the wide influence over the English mechanics which he exercised for the rest of his life. One of the machines for making pulley blocks is shown in Fig. 2. It was used for cutting the groove for the fixed rope or cable. Two blocks were chucked by clamps on a swinging frame *D*, which also carried a former *G*. The cutting wheels *E* were guided in their path by a disk *H* which was in contact with the edge

* The following articles relating to the history of machine tools and kindred devices have previously been published in MACHINERY: "How we came to have the Micrometer Caliper," June, 1915; "An Early Automatic Gear Cutting Machine," September, 1913; "An Old Gear Cutting Machine," March, 1913; "Donkin's Dividing Engine—Early Machine Tools," August, 1910; "Primitive Boring Machines," July, 1910; "Chapters in the Early History of Machine Tools," September, October, November, 1909; "Recollections of an English Machine Shop," June, 1903; "Early Machine Shops and Mechanics," October, 1902.

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of the former-plate *G*. Maudslay & Field's shop became one of the most influential in the whole world. Joseph Clement, Richard Roberts, Sir Joseph Whitworth, James Nasmyth, and a host of others less well known, worked there; going to other shops, they laid the foundation of the supremacy which England had in tool building for two generations.

Development of the Planer

The planer, a development and inversion of the slide-rest, was invented independently by a number of men. Claims have been advanced for no less than half a dozen. Matthew Murray, of Leeds, is said to have built one as early as 1814 to plane the surfaces of D slide-valves, which were invented by Murdock, Watt's assistant, but were improved by Murray, who seems to have been the first to manufacture steam engines operated by them. Richard Roberts, of Manchester, was another of the inventors of the planer. The South Kensington Museum has a planer built by him in 1817, one of the oldest machines still in existence. It was hand-operated, with a chain-driven bed 52 inches long and 11 inches wide. Its general design is quite like that of the modern planer. It has vertical and horizontal feeds, angular adjustment and separate tool feed for the head, and a hinged tool clamp to allow the tool to swing clear of the work on the return stroke. The chisel and file marks on the bed and ways indicate that the machine was made without the aid of another planer.

James Fox, of Derby, the founder of a well known tool building concern, is said to have built a planer about 1821 for the manufacture of the frames of lace-making machinery. George Rennie, a brother of Sir John Rennie, also built a planer about 1820 without knowledge of the others existing at that time. Joseph Clement built a remarkable machine about 1825 which is illustrated and described in the *Transactions of the Society of Arts*, London, 1832. It took in work 6 feet square and about 12 feet long, and was for years known as "the great planer." The bed ran on rollers and is said to have been so accurately mounted that if a piece of paper were put under one of the rollers the rest would stop. It was arranged to cut on both the forward and backward strokes. "The power of one man was sufficient to keep it in motion for ordinary work, though two were employed to make long and full cuts both ways." For more than ten years it ran day and night on jobbing work and formed the principal source of Clement's income. Smiles says that his charge for planing, which was 18 shillings or $4.32 per square foot, amounted to about ten pounds for a day of twelve hours; or, with two shifts, to about $100 a day.

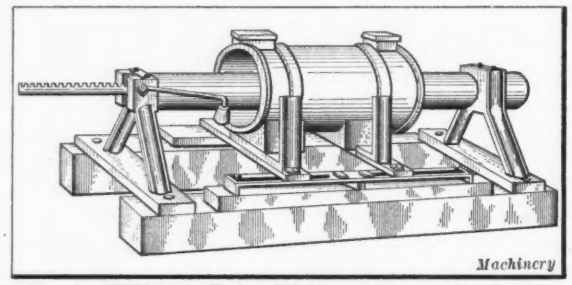

Fig. 1. Wilkinson's Boring Machine which may be classed as the First "Modern" Type of Machine Tool

Nasmyth and His Inventions

James Nasmyth was one of Maudslay's pupils. Nasmyth's autobiography, edited by Samuel Smiles, is a book which anyone interested in mechanics will read with pleasure. Nasmyth had played in his father's private workshop from earliest boyhood, and before he was twenty had become an expert mechanic with one ambition in life, to work for the great Mr. Maudslay. He went to London with his father, and together they called on Maudslay, who showed them courteously through his plant. Maudslay at first declined to consider employing Nasmyth, as he said he had never had any success with gentlemen apprentices and had definitely determined that he would never employ another. Nasmyth, however, showed him a number of drawings and a working model of a steam engine which he had brought with him from Edinburgh. Maudslay at once perceived that Nasmyth was an extraordinarily skillful workman, and he not only employed him, but took him into his own office as his personal assistant. Nasmyth stayed here for several years, until Maudslay's death in 1831, when he started in business for himself. He became one of the foremost tool builders in England, and invented the shaper which was long known as Nasmyth's "steam arm." While still with Maudslay he invented an index milling machine, shown in Fig. 3, for milling the sides of hexagon nuts. He was the inventor of the foundry ladle tilted by a worm and gear between the frame and ladle. Prior to that time, ladles were operated by hand-levers and were a source of frequent and serious accidents. Nasmyth generously refrained from patenting his invention in the interest of the safety of the workmen, and its use soon became general.

His greatest contribution to the machine-building trade was the steam hammer, invented in November, 1839. Before he had had time to build one, the immediate need for it passed and he did nothing further with it. His sketch of it, however, was shown from time to time to various people, among them M. Schneider, of Creuzot, France. In 1842, three years after the sketch was made, Schneider showed Nasmyth, when in France, some wonderful forgings, made, he said, on his steam hammer. Nasmyth, in wonder and surprise, was taken out to the forge shop and saw for the first time the steam hammer which he himself had invented. Fortunately he could still cover the machine by patent, and two months later one was obtained. The history and the influence of the steam hammer are well known. This tool enormously increased the facilities for manufacturing heavy machinery.

Whitworth as a Factor in Machine Tool Development

The work of the earlier generation of English tool builders culminated in that of Sir Joseph Whitworth. He, like most other English mechanics, was a North-country man, who had worked for both Maudslay and Clement. The succession of influence running through these men is singularly illustrated in the development of standard screw threads. Maudslay standardized the screw-thread practice of his own shop, settling upon and adhering to a definite number and size of threads for each size of screw then in use. Clement, who worked for Maudslay, adopted these standards, improved them, began the manufacture of taps and dies, and invented the tap having a small shank to enable it to fall through the tapped hole, thereby avoiding the necessity of backing out the tap. Whitworth took up the work of Clement and Maudslay, and after making a careful study of all the threads in general use, proposed, in a paper before the Institute of Civil Engineers in 1841, the standard which became general throughout the country and continues today as the Whitworth standard thread.

Most of the general tools had been invented by the time Whitworth began his independent work, but he so improved their design and workmanship that he dominated English tool practice for several generations. He introduced an accuracy in commercial work unknown until that time, which was made possible by his improvements in the methods of measurement. His gages became the standard for the country and, in fact, for the world. In 1853, Whitworth visited the United States as a member of an English commission, and it was through the recommendation of this commission that American gun machinery and interchangeable methods were introduced into England. He had an enormous influence on the development of rifles and artillery; his work in this field alone would mark him as one of the great mechanics. The very ascendancy of Whitworth's methods seems to have been an element in the loss of mechanical leadership by the English tool builders. In 1850, Whitworth was the most advanced tool builder in the world, but so great was his authority that the English mechanics adhered to his designs and methods for the next fifty years, and the leadership in tool building gradually shifted to America.

Early American Machine Tools

Tool building in America began at about the same time as in England, and has two quite independent sources. In 1789, Samuel Slater, an English mechanic, trained under Arkwright,

escaped the embargo and came to America. After a short stay in Philadelphia, he settled in Pawtucket, R. I., and there built the first textile machinery made in America. Northern Rhode Island was the home of a race of mechanics. The names of Jenks, Wilkinson, Brown, and Greene, continually occur in the records of the beginnings of manufacture in New England. Slater soon became a leader among those about him. He was a good business man, as well as mechanic, and to him more than to any other one man is due credit for the rise of the New England cotton industry. General machine tools were developed in America by these mechanics to manufacture cotton machinery, and for nearly a generation the machine industry centered about the Narragansett Bay. From here it gradually spread northward. In 1822, Slater, Larned Pitcher and Ira Gay took over a small textile enterprise in Manchester, N. H., and founded the Amoskeag Mfg. Co. Though now known as one of the greatest textile mills in the world, it manufactured in its early years locomotives, engines, boilers, machine tools, and all kinds of textile and general mill machinery. Its influence was great, and assisted materially in the development of Nashua, Lowell and Lawrence. Ira Gay left Pawtucket and later founded Gay, Silver & Co., in North Chelmsford, Mass., which, although a small shop, has been one of considerable influence.

With the development of steam navigation, Providence outgrew Pawtucket in commercial importance, and became, and has always remained, a great manufacturing center. Many of the shops which have become famous had their beginnings in the early part of the last century. The Builders Iron Foundry was started about 1820. The Rhode Island Tool Co. had its beginnings in 1834 with Jeremiah Arnold, who worked as a young man for David Wilkinson. The American Screw Co. began with the Eagle Screw Co., organized in 1838 by William Angell.

Joseph R. Brown and American Machine Tool Development

The largest of the Providence shops, the Brown & Sharpe Mfg. Co., one of the most influential in the world, was established in 1833 by David Brown and his son, Joseph R. Brown.

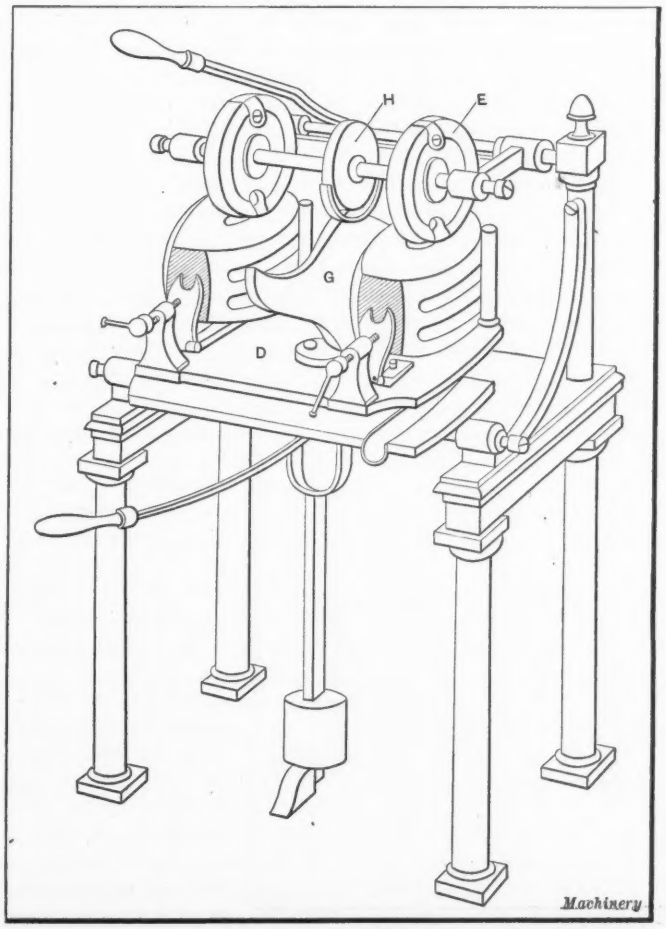

Fig. 2, One of the Machines built by Maudslay for making Pulleys for the Portsmouth (England) Navy Yard

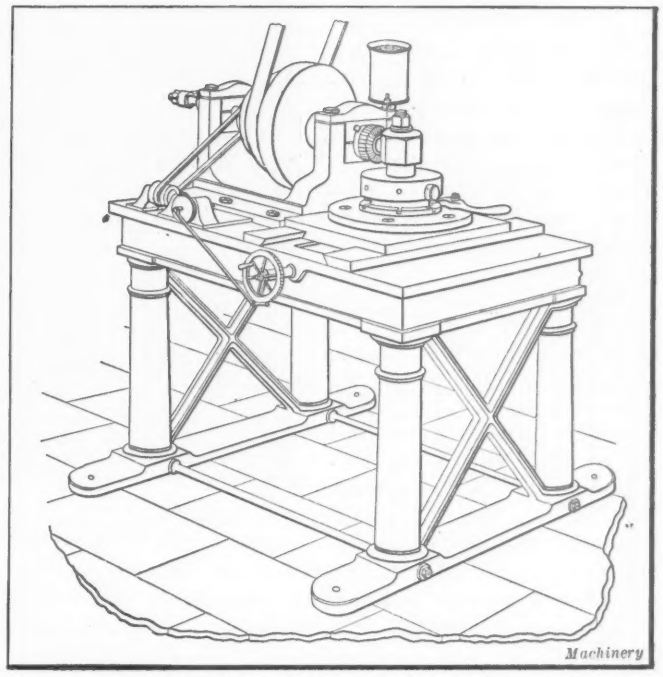

Fig. 3. Index Milling Machine designed and built by Nasmyth about 1830

Their business at first was the repairing of watches and clocks and the making of mathematical instruments. About 1850, Joseph R. Brown developed a linear dividing engine and the next year brought out the vernier caliper, reading to thousandths of an inch, which for the first time made accurate measurements possible for the everyday mechanic. The micrometer caliper, inseparably connected with the name of Brown & Sharpe Mfg. Co., was brought out in 1867. The general principle of the measuring screw is very old, and was in use in England more than 200 years ago. Watt had one, and Nasmyth tells of one built by Maudslay, which he called "the Lord Chancellor." Whitworth had before this developed measuring machines of marvelous accuracy on the micrometer principle. In all cases, however, they were either machines standing upon a bench, or were so large and clumsy as to preclude their general use. Combining a design of Mr. Wilmot, of Bridgeport, with a system of graduations devised by a French mechanic named Palmer, Mr. Brown developed the micrometer as we know it today. It is hardly necessary to call attention to the immense influence this instrument has had in the spread of good workmanship throughout all mechanical trades. As early as 1855, the Brown & Sharpe Mfg. Co. also built precision gear-cutting machines; in 1861, Mr. Brown developed the universal milling machine in order to mill the grooves in twist drills; his company also developed the relieved milling cutter, and was largely responsible for the use of diametral pitch in America. The universal grinding machine was evolved by him for the purpose of grinding hardened sewing machine parts. While by no means the originator of the automatic turret screw machine, the firm has long been one of the foremost builders of this type of machine.

Other New England Machine Tool Centers

With the spread of machine shops north from Pawtucket, Worcester became the center of tool building. A number of small shops had grown up there to manufacture textile machinery, and by 1840 these had come to have a wide influence. Samuel Flagg established the first tool building shop in the city in 1839. An apprentice, L. W. Pond, trained in this shop, ultimately bought out the business, which became the Pond Machine Tool Co., was moved to Plainfield, in 1888, and is now part of the Niles-Bement-Pond Co. In Fitchburg, nearby, the two brothers, John and Salmon W. Putnam, laid the foundations of the Putnam Machine Co. They, too, began manufacturing cotton machinery and later developed their business into the manufacture of tools. They were also manufacturers of steam engines, and had an important part in the invention of the rock drill.

Eli Whitney and Interchangeable Manufacture

The American development considered so far sprung directly or indirectly from the first of the two sources mentioned, namely, the early influences in and about Pawtucket; but the most typically American development came from another source. Eli Whitney graduated from Yale University in 1791, and in the fall of the same year he developed the cotton gin, one of the few great inventions clearly traceable to one man. Despite the fact that his patent was ultimately sustained, widespread infringements and long, expensive litigation deprived him of any adequate financial reward. Whitney, who was a clear-headed business man, saw that he would never realize much from it, and turned to the manufacture of an unpatented article, relying upon improved methods. In 1798 he obtained a contract from the government for 10,000 muskets, built a shop in the outskirts of New Haven, and laid the foundations of the interchangeable system of manufacture. Using limit gages, milling machines and rude jigs, he demonstrated that guns could be manufactured by machine tools not only interchangeably but more cheaply than by the old hand methods. About the same time, Simeon North, a gun-maker in Middletown, Conn., obtained contracts for pistols, and began a connection with the government which lasted for fifty years. A later contract signed by him in 1813 contained the first clause specifying interchangeability; "the component parts of pistols are to correspond so exactly that any limb or part of one pistol may be fitted to any other pistol of the 20,000." It is probable that the North contract of 1813 was not so much the beginning of a new method as the recognition of one which had already come into existence, for Whitney's letters and the reports of Capt. Wadsworth, the government inspector, show clearly that Whitney, at least, had been developing the idea from the "very beginning," that is, from 1798. Whitney was probably the earlier of the two, but it is certain that North was not far behind. There is no evidence that the two men knew each other or had any communication, but it seems improbable that two manufacturers, in closely allied industries, but twenty miles apart, should not have been more or less familiar with each other's work and influenced by each other's method. It is certain that the interchangeable system as a successful process of manufacture had its birth in the work of these two men. There is no question as to which had the greater influence. Whitney was already well known through his cotton gin, was located in the larger center, and did more than North to spread the system elsewhere. The armory which he founded continued in business for ninety years, when it was sold to the Winchester Repeating Arms Co. Samuel Colt had his first pistols made by the Whitney Arms Co., and when he went to Hartford to build the Colt armory in the early fifties, he not only adopted their methods of manufacture but greatly extended them. E. K. Root, his superintendent, built the new armory and designed much of its machinery. It was without question the most highly developed manufacturing plant in existence at that time, having over 1400 machines, with tools and fixtures costing about as much as the machines themselves, a proportion unheard of before. Famous mechanics worked there, among them F. A. Pratt and Amos Whitney, of the Pratt & Whitney Co., C. E. Billings and C. M. Spencer, of the Billings & Spencer Co.

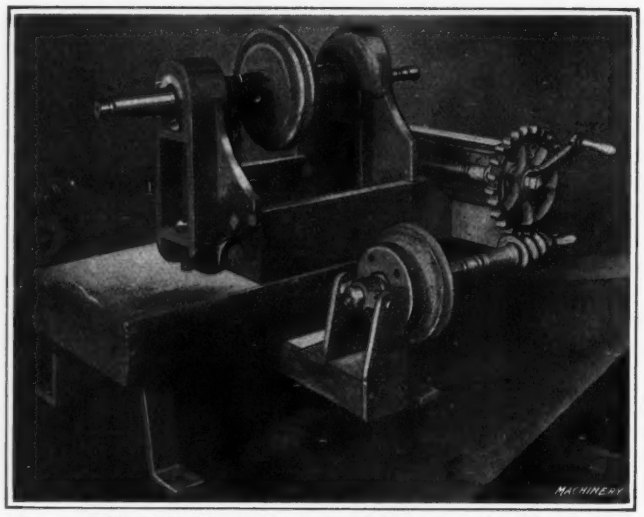

Fig. 4. Milling Machine built by Eli Whitney about 1818, supposed to be First Milling Machine built. Now in the Mechanical Engineering Laboratory of Yale University

Northern New England's Machine Tool History

Of the early gun shops three stand out clearly by reason of their far-reaching influence. The Whitney and Colt armories are two, and the third is that of Robbins & Lawrence, of Windsor, Vt., which was started a few years earlier than the Colt armory. It was one of the plants visited by the English commission in 1853, and furnished much of the machinery that was installed at Enfield. The work of R. S. Lawrence, Frederick W. Howe, and Henry D. Stone gave it wide recognition. Lawrence was a self-trained mechanic and a born gun-maker. Howe served his time in the old Gay & Silver shop at North Chelmsford, and brought from there the beginnings of the Lincoln type of miller and the turret lathe. Fig. 5 shows the Robbins & Lawrence milling machine which was a forerunner of the Lincoln type. The illustration is made from a reproduction of a drawing made by F. W. Howe, about 1853. The improvement introduced by F. A. Pratt, which differentiated the Lincoln milling machine from the machine shown in the illustration, was the substitution of a worm-feed for a rack-and-pinion drive for the table. From the Robbins & Lawrence shop Howe went to Providence as superintendent of the Providence Tool Co., and later to the Brown & Sharpe Mfg. Co. From the Robbins & Lawrence shop also sprung the Sharps Rifle Works at Hartford, which became the Weed Sewing Machine Co.; later the Pope Mfg. Co.; the White Sewing Machine Co.; the Cleveland Automatic Machine Co., of Cleveland; and the Sullivan Machinery Co., manufacturing mine equipment at Claremont, N. H. Although the old shop at Windsor passed through a number of hands, it was for many years under the superintendency of Henry D. Stone. In 1879 the company, which had become the Jones & Lamson Machine Co., moved to Springfield, Vt., and has taken a leading position among the world's builders of machine tools. Its later development is largely due to James Hartness, the inventor of the flat turret lathe, who became superintendent in 1889.

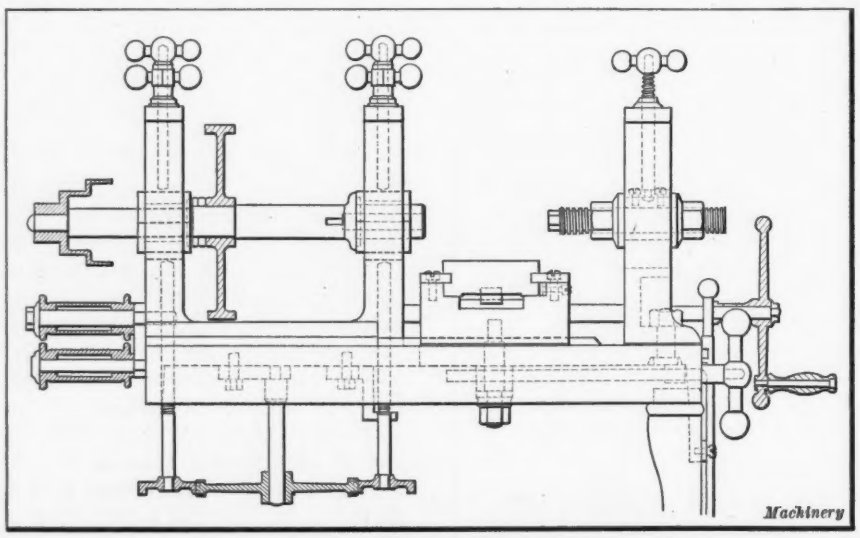

Fig. 5. Robbins & Lawrence Milling Machine reproduced from Drawing made by F. W. Howe about 1853

The interchangeable system is characteristic of many other industries, such as the manufacture of sewing machines, clocks, watches, typewriters, etc., but they did not originate it. Starting later, these industries utilized

and developed a system already in existence. It is quite natural that the system should have been developed, as it was, by the gun-makers, since guns, particularly for military purposes, were the first articles produced in great numbers where interchangeability was clearly desirable.

Machine Tool Development in Philadelphia

Under the leadership of William Sellers and William Bement, Philadelphia took the leadership in tool building for the next generation. Bement was a New England man who, like so many others, began his work in the manufacture of textile machinery. He was a leading workman in the old Amoskeag shop and later in the Lowell machine shop. Sellers was a Pennsylvanian who received his training at Wilmington, but was for several years superintendent of the machine shop of Fairbanks, Bancroft & Co., in Providence. Three years later, in company with Mr. Bancroft, he founded the business of William Sellers & Co. There is a singular parallelism between the work of Sellers in America and of Whitworth in England. Both were superb mechanics, of commanding influence, and each standardized the screw thread practice of his country. Both Bement and Sellers are identified more with heavy machine tools than with the lighter ones; the latter have always been associated with New England.

Machine Tools in the Middle West

The spread of machine-tool building westward has been the characteristic feature of the past generation. W. R. Warner and Ambrose Swasey in Cleveland, both of them foremen with the Pratt & Whitney Co., in Hartford, have taken westward the best traditions of the New England mechanics. They have not only extended the reputation of the American mechanics for tool building, but are the foremost builders of large telescopes. Cincinnati was the center of engine building and repair work in connection with the old river traffic in the Mississippi valley. With the decay of this traffic, the attention of mechanics was turned in another direction, very largely through the influence of William E. Lodge, who went there as a journeyman mechanic in the early seventies. He was president of the Mechanics Union and widely known among the workmen of the city. In 1880, having saved a thousand dollars, he started in business for himself. His rapid success encouraged many of his old friends to undertake the manufacture of machine tools, and a large number of successful companies, each specializing in a single type of tool, has resulted. At the present time, Rockford, Ill., and Milwaukee and Madison, Wis., are becoming machine tool centers of importance.

Conclusion

Early machine tool manufacturers in the United States by no means confined themselves to copying the tools that were developed in England. The wide-spread commercial use of jigs, fixtures, and limit gages is distinctly American in origin. Maudslay's slide-rest made the lathe possible, but the turret and cam control, developed by the New England gun-makers, made it fully automatic, and enormously extended its capacity as a manufacturing machine. The board drop-hammer was also developed by the gun-makers, at Harper's Ferry, Ilion, and at Colt's. Boring mills seem to have been first used by Bodmer in Manchester, England under the name of rotary planers, but their present development is American. The same is true of precision grinding machinery and the universal milling machine. Milling, as a manufacturing process, while not original in America, has been greatly extended and refined here. In the broad sense, the great contribution of America has been the automatic machine tool and the extension of precision methods to production on a large scale.

* * *

MILLING CLUTCH TEETH ON STEM-GEARS

The New Process Gear Corporation, at its factory in Syracuse, N. Y., manufactures a great many nickel-steel stem-gears on one end of which there is a three-jawed clutch. The shanks of these stem-gears are approximately two inches in diameter, there is a 1-inch hole through the center, and the three-jawed clutch is proportioned about as

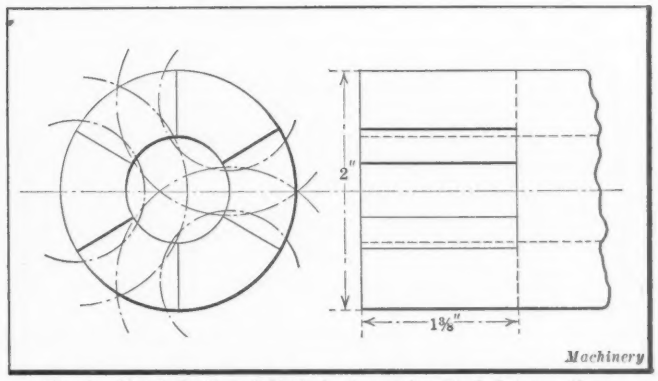

Fig. 1. Clutch Teeth and Method of removing Stock between them

shown in the line illustration, Fig. 1. The clutch teeth are milled 1⅜ inch deep. It will be readily appreciated that machining these by passing a milling cutter straight through from one tooth to the other would not remove quite all the stock; there would remain a small triangular section in each of the milled sections, which would have to be removed by end-milling. In looking for a quicker way of removing this stock, it was decided to try hollow-milling. Accordingly, a circular hollow mill was made that would remove the bulk of the metal from the two spaces adjacent to one of the clutch teeth in one cut. The milling cutter was made 5/16 inch wide and of a radius that would just clear the tooth and mill away most of the stock from two adjacent sections. By setting the cutter properly, three passes clean out the stock, except for a small section on the side of each tooth, as shown in Fig. 1.

Fig. 2 shows the fixture and cutter as used in the drill press. The stem-gear is inserted from below, and by means of a strap and swing-bolts is clamped in position. The top of the fixture has three bushings spaced 180 degrees apart and these are used successively to guide the cutter for the three operations necessary to complete the milling. The base of the fixture is strapped to the table, but the housing may be turned to bring the work into the three milling positions. After the circular milling has been done, the sides of the teeth are finished by running through a straight milling cutter to size and clean up the sides of the clutch teeth. Three cuts finish the job. An operator can do the circular milling on eight stems per hour. C. L. L.

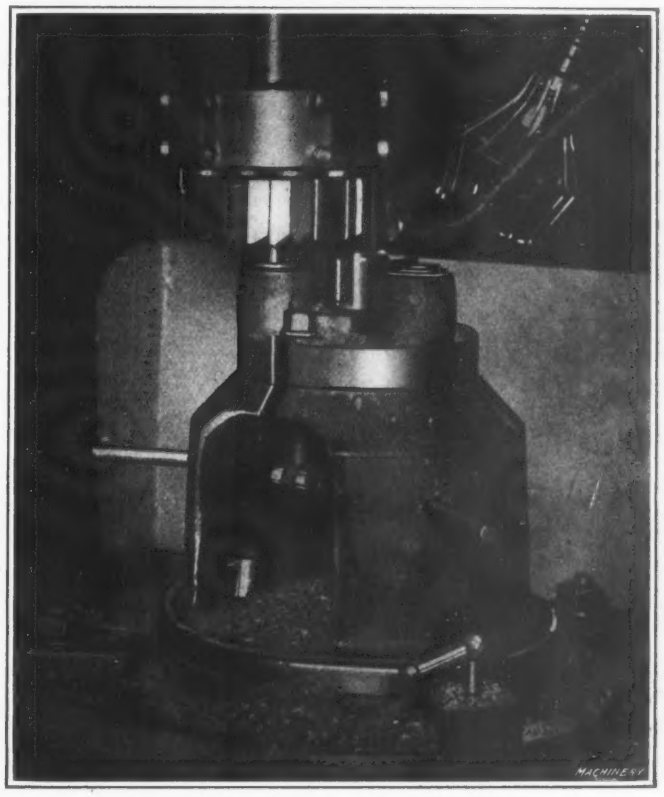

Fig. 2. Cutting Teeth with Hollow Mill

TURNING IVORY BILLIARD BALLS

HIGH DEGREE OF ACCURACY AND FINISH OBTAINED WITH SIMPLE TOOLS

BY EDWARD K. HAMMOND*

IT WILL doubtless surprise all mechanics who are familiar with the degree of accuracy and perfection of finish which is demanded on the highest grade of ivory billiard balls to know that the work of turning them is done with an extremely simple outfit of tools. Successful billiard ball turners depend upon the skill they have acquired through years of experience in the trade, rather than upon the use of mechanically controlled machining contrivances. The turning is done on a speed lathe, and the complete set of small tools is illustrated in Fig. 1. In setting up a lathe for ivory turning, particular care must be taken to have the bearings fit the spindle accurately, and to have the lathe bolted down to a solid foundation. If these precautions are not observed, vibration is likely to develop, which will make it impossible to obtain the required degree of accuracy and perfection of finish.

The Ivory that is Used

It is a matter of general knowledge that ivory is obtained from elephants' tusks, but there are probably few persons

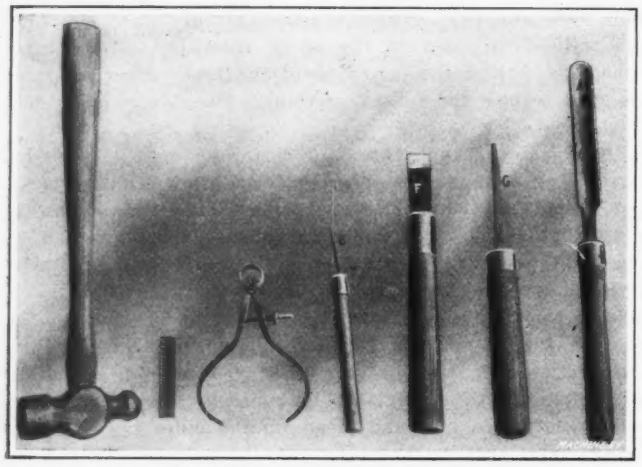

Fig. 1. Complete Set of Tools required for turning High-grade Ivory Billiard Balls

who are aware of the fact that the quality of the ivory varies greatly according to the part of the world in which it is obtained. Commercial ivory may be roughly subdivided into "hard" and "soft" ivory, and for use in turning billiard balls the soft ivory obtained from East Africa is far superior. There are several reasons for this, most important of which is that the soft ivory is more easily worked by cutting tools; also, it is not so liable to be cracked by the impact of the billiard balls while in use, or by sudden changes in climatic conditions. The ivory comes to the billiard ball turner in short cylindrical shaped pieces known as "blocks," which are nothing more nor less than sections obtained by sawing them from the tusks at the point where the latter are slightly larger than the required diameter.

The market price of ivory is in the neighborhood of $4.50

*Associate Editor of MACHINERY.

Fig. 2. Roughing out the Ball, showing how Rings are obtained

per pound, and this high price makes it necessary to work the material as economically as possible; hence only those portions of the tusks are used which are of sufficient size to enable a ball to be turned with the minimum amount of waste. This need for economy imposes a further test upon the skill of the billiard ball turner. Pool balls range from 2¼ to 2½ inches in diameter, and billiard balls are 2⅜ to 2½ inches in diameter, while the sizes of the ivory blocks from which the balls are turned are such that there is only an excess of from 1/32 to 1/16 inch of stock. Consequently, it will be evident that great care must be taken to prevent spoiling the work.

By-Products in the Billiard Ball Industry

Another interesting point about billiard ball turning is that the work is done in such a way that from six to eight ivory rings are secured as by-products in turning out each ball. The average mechanic confronted with the problem of turning a billiard ball from a commercial ivory block would naturally think that the method of procedure is to first rough out the ball and then finish it by one of the methods commonly used for turning a sphere; but while such a method would be satisfactory when working in metal, the cost of ivory is so high that the amount of material wasted would involve a serious loss. To overcome this waste, the ivory turner has developed a method of procedure by which six or eight rings are secured as by-products. These rings are of various forms and are used on high-grade harnesses, by horse breeders, and for various other purposes. While the production of these rings enables the amount of ivory wasted to be greatly reduced, the method also imposes a further test upon the skill of the turner.

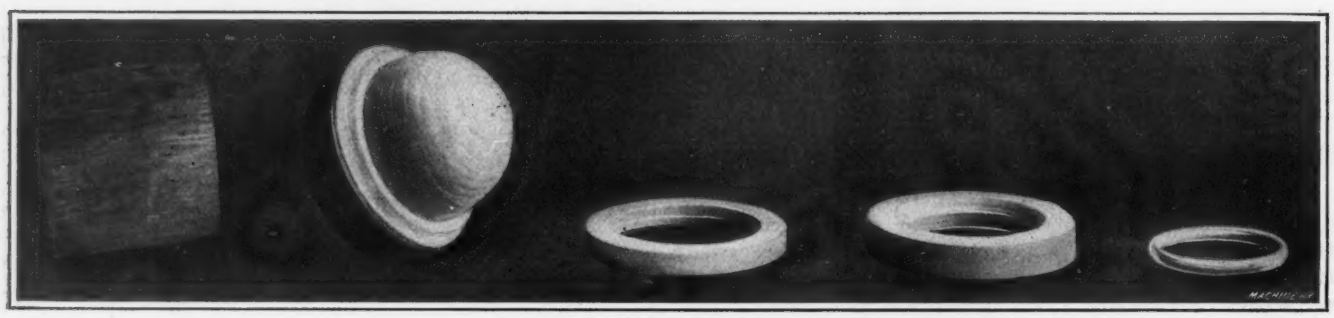

Fig. 3. Natural Ivory Block, Ball half roughed out, and Three Rough Rings obtained from First Half of Block

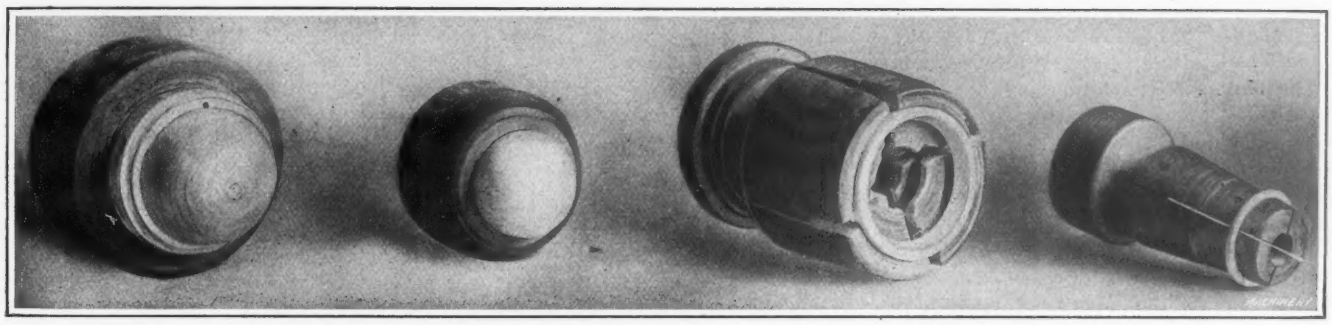

Fig. 4. Types of Chucks used for Roughing and Finish-turning Operations on Balls and Rings

The following description applies to the methods of turning billiard balls employed by Phil. Jost, Jr., 102 N. Franklin St., Chicago, Ill., and the illustrations are reproduced from photographs taken in his shop. The lathes on which the turning is done are fitted with wooden chucks which are made of either dog-wood or beech-wood. Beech-wood chucks provide the best gripping surface, but difficulty is experienced with chucks made of this material owing to the tendency for the threads to strip when the chuck is screwed onto the lathe spindle. This trouble is not so likely to occur with dog-wood chucks, and their gripping power is practically as good.

The form of chuck used for the first operation has a conical shaped gripping surface, and the ivory block is first ground down at one end on a disk wheel so that it can be driven into the chuck by striking it with the end of the hammer handle. In setting up the block ready for the first operation, care must be taken to have it run practically true in order that all of the ivory in the block will be available for turning the ball and rings. With the work set up in this way, the turner first uses the gouge *A* to take a light roughing cut over the outside of the block, and then he takes the tool *B* and starts to work in at the end of the block to bring it to the condition shown in Fig. 2. From this illustration it will be seen that a start has been made on the spherical surface and that there is also a small ring *C* which is practically ready to be cut off. The turning tool used for doing this work is ground up from an old file and is somewhat similar to a very thin parting tool, the cutting end being square with a slight clearance provided on each side of the blade. The temper of the steel in the file is drawn considerably so that the tool is fairly springy and not very brittle.

After the small ring *C* has been removed, the turner continues to work in from the end of the block until a considerable depth has been reached; then he cuts in from the side of the block as shown in Fig. 2, in order to remove the first large ring *D*. When this large ring has been removed, the turner continues to work out the spherical surface from the end of the block, and after he has cut in far enough another large ring is removed, as indicated at *E* in Fig. 2. Half of the rough ball has now been formed, the work having reached the condition shown in Fig. 3. The block is next removed from the chuck and set up in the reverse position, so that the rough end of the block is exposed ready to continue the turning operation. A different form of chuck is used for this purpose, which has a hemispherical cavity into which the rough ball is driven. After the block has been set up, the turner works in the manner previously described, roughing out the other half of the ball and obtaining a similar number of ivory rings as by-products.

Fig. 5. Method of performing Final Turning Operation

Finishing the Ball

After the rough ball has been obtained, it is still held in the chuck used for the second rough-turning operation, and the tool shown at *F* in Fig. 1 is used for removing the tool marks left in roughing out the ball and also to bring it to the condition of a more nearly perfect sphere. The method of procedure is shown in Fig. 5, where it will be seen that the only assistance given the operator in guiding his tool is that afforded by an ordinary handrest. After half of the surface of the ball has been turned in this way, a sharp lead pencil point is applied to the revolving ball to draw a line around it. The ball is then removed from the chuck and set up in the reverse position so that the pencil line is in approximately the same position that it formerly occupied. The same method is then followed in turning the opposite half of the ball.

After the work has progressed to this point, the ball is again removed from the chuck and set up on the reverse center, *i. e.*, while the axis of the lathe spindle was formerly perpendicular to the plane of the lead pencil circle drawn on the ball, it now lies in the plane of this circle. The turner now goes over the surface of the ball a second time, scribes another lead pencil circle in a plane perpendicular to that of the first circle, reverses the work in the chuck and turns

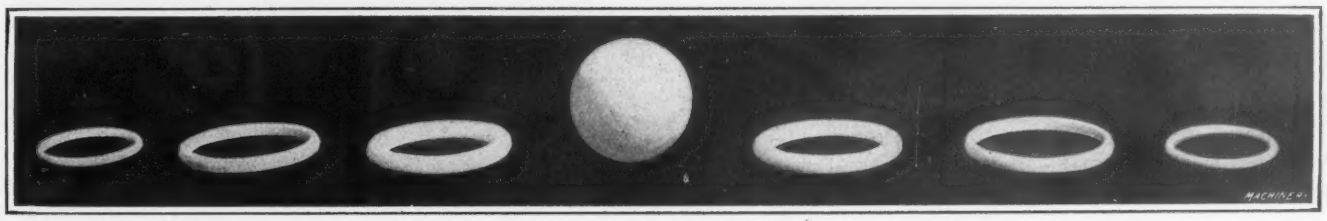

Fig. 6. Complete Finished Products secured from a Single Ivory Block. In Some Cases Two Additional Rings are obtained

the opposite side of the ball. When the work has reached this condition, the turning of the ball is practically completed.

The ball is tested for accuracy by applying a very sharp lead pencil point so that it just touches the surface of the work, and noting whether a uniform line is left as the ball rotates; the ball is then turned in the chuck and the test repeated. If uniform lines are drawn in two positions of the ball at right angles to each other, it shows that there is only a negligible amount of error in sphericity. The ball is next taken to a polishing lathe where it is set up in a similar chuck to that used for the finish-turning operation. The preliminary polishing is done with a fine grade of sandpaper that removes all tool marks from the surface of the ball, after which a white diamond polishing cake, made by the Matchless Metal Polish Co., New York City, is used to remove all scratches left by the sandpaper. After the complete surface of the ball has been gone over with this cake, the final polish is obtained by rubbing the ball with a cloth saturated with alcohol, while it is held in the rotating chuck. The finish obtained in this way is that with which we are familiar on the highest grade of billiard balls.

Turning the Rings

Fig. 3 shows the ivory block as it was cut from the elephant's tusk, the condition of the work after half of the ball has been roughed out, and the three rough rings obtained from half of the block. The method of procedure in finishing the ball has already been described, and we are now concerned with the way in which the rings are finished. The two forms of chucks used for this purpose are shown at the right-hand side in Fig. 4, where it will be seen that one is of similar design to a collet, except that the grip on the work is obtained by the spring in the wood; while the other is an expanding chuck which secures its grip in the same way. In roughing out, the rings are placed in the internal chuck and reduced to approximately the required shape. The tool used for turning the rings is shown at *G* in Fig. 2. The finishing operation is generally performed with the ring held on the expanding chuck shown at the extreme right-hand side of Fig. 4, and this chuck is always used for finishing the small rings shown at the extreme ends in Fig. 6, which are the finished products obtained from a single ivory block. That such a high quality of workmanship can be obtained with such simple tools speaks highly for the skill of the men employed in this industry.

* * *

MAKING SLUSH CASTINGS*

The process of slush-casting is used extensively in the manufacture of ornamental objects of spelter or zinc. Hollow and therefore relatively light castings are produced. The molds used are of metal, usually bronze or brass which can be machined evenly and which will not be injured by the molten metal. Faithful reproduction of intricate designs can be made by this means provided a metal suitable for casting purposes is available which melts at a relatively low temperature and which will not crack and pull apart under cooling stresses. The process is substantially as follows:

The metal is poured into the hollow mold until it is full and then the mold is immediately emptied, leaving a thin-walled casting chilled upon the inside surface. The mold is usually mounted upon trunnions or otherwise arranged to facilitate rapid emptying.

Because of extensive use for ornamental purposes castings so produced are often plated, stained or treated in other ways to produce color effects. Therefore other properties are required of the cast metal besides that of perfection of surface and accurate reproduction of pattern. The surface must not only be a faithful reproduction of the mold with a smooth surface but must be free from small cracks or pin-holes. A large flaw which can be readily seen can be removed by chipping and filling with solder, or the casting may be rejected and remelted, but a small flaw may escape a careful inspection; flaws of this kind may take up and hold some of the liquor from the plating solutions and thus cause a stain to appear later. Hence, for good work, it is necessary to use a metal which will give castings entirely free from cracks or flaws of any kind. Following are some conditions that must be borne in mind both as to the metal used and the casting practice: (1) The production of as light castings as possible, consistent with the strength demanded by the use to which they are to be put, thus making for economy in metal. (2) The use of a metal that is subject to minimum losses of oxidization, drossing, etc., while standing molten in the pot. (3) The production of as large a percentage of perfect castings as possible, thus cutting down the loss of time and labor to a minimum.

These three factors necessarily interfere to some extent. Their dependence on the conditions of operating is very close. Economy in the use of metal is possible only with a metal possessing a small solidification range and high fluidity at the time of casting. A high casting temperature will aid this. Economy of metal as regards loss by oxidization at the surface is obtained only by low casting temperature and the least possible manipulation of the bath. This conflict between the high and low casting temperatures as required by the first and second conditions means a compromise decided by experience. Economy of time depends upon the employment of a reliable metal, one giving uniformly dependable results, and experience on the part of those handling the process, together with the strictest attention to the control of the operating conditions. The constant use of the thermocouple and galvanometer should replace judging temperatures by the eye.

The common impurities of spelter are cadmium, lead, iron and zinc. The American Society for Testing Materials has separated the spelter into four grades depending upon the amount of impurities present as follows:

High-grade spelter shall contain not over 0.5 per cent cadmium, 0.7 per cent lead, and 0.3 per cent iron, and the sum of these impurities shall not exceed 0.10 per cent.

The intermediate grade of spelter shall contain not over 0.5 per cent cadmium, 0.2 per cent lead, 0.3 per cent iron, and the sum of these impurities shall not exceed 0.5 per cent.

Brass special spelter shall contain not over 0.75 per cent cadmium, 0.75 per cent lead, 0.04 per cent iron, and the sum of these impurities shall not exceed 1.2 per cent. No aluminum is allowed in any of the foregoing spelters.

Common or prime western spelter shall contain not more than 1.5 per cent lead and 0.08 per cent iron.

The qualities required to make up a perfect casting metal may be summed up as follows: (1) The metal must yield casting free from cracks or flaws of any kind. (2) The surface must be smooth and bright. (3) The weight must be low enough to be economical. (4) The metal must not be too sensitive to variations of temperature of pouring.

* * *

About two years ago, the General Electric Co. announced that its research laboratory had developed a process for the protection of metals subjected to high temperatures. The process, originally called "calorizing," produced a rich aluminum alloy upon the surface of the metal to be protected. In other words, the metal is insulated with aluminum, from which was derived the name "insuluminum." The process by which insuluminum is produced consists briefly in packing the parts in a mixture consisting of alumina, powdered aluminum and ammonium chloride in a gas-tight crucible. The crucible is filled with a reducing or inert gas to prevent oxidization of the aluminum. The temperature is slowly increased until it reaches 1742 degrees F. at which temperature the pieces are held for approximately three hours. The process is similar to the cementation process used for converting iron into tool steel. The result is not a coating of aluminum but an alloy of aluminum with the metal beneath. The claim is made that steel pipe treated by the insuluminum process will withstand exposure to combustion gases without deterioration at a temperature from 800 to 1700 degrees greater than the uncalorized metal can withstand. Experiments have been made at temperatures of about 2500 degrees F. on calorized pipe without causing apparent deterioration. Sulphur dioxide gas at high temperatures has little or no effect.

* Extract from paper presented at the annual meeting of the American Institute of Metals, held at Atlantic City, N. J., September 28 to October 1.

RECENT LEGAL DECISIONS INVOLVING MACHINERY

Ford Sale Contracts Uninforcible

(Federal) The United States District Court, Southern District of Ohio, has recently held in Ford Motor Co. v. Union Motor Sales Co. that the form of sale contracts used by the Ford Motor Co. is in restraint of trade and uninforcible. The Ford Motor Co. manufactures "flivers" under its own patents and sells the same to dealers, receiving therefor the prices it has fixed, but by contracts with such dealers it is provided that the machines will be resold by them at the full advertised list price only, and that a violation of such provision shall constitute an infringement of the patent, subject the dealer to the payment of a fixed sum as damages, and authorize a cancellation of the contract; also that title to the particular machine or machines so sold shall revert to the Ford Motor Co.

The Union Motor Sales Co., the Cincinnati distributor, sold Ford cars in violation of its contract. The Ford Motor Co. brought this suit to recover damages and to cancel the contract of agency.

The District Court held that the contract was one of sale of the machines, and not the right to sell, that on full payment of the purchase price of a machine it passes beyond the patent monopoly, and that so far as the contract attempts to fix the price at which only it may be sold thereafter it is illegal, as in restraint of trade and uninforcible. Justice Hallister said in part, "For the purposes of this case it may be assumed that if the contract partakes of the quality of a sale, of the exclusive right to sell, or of a license to sell, it is a good contract, which the complainant may legally enter into with its dealers, and, under the facts proved in this case, an injunction must issue against the defendants. But if, under the terms of the contract, the complainant has sold the automobiles made by it and delivered the same to its dealers, passing the title upon receipt of the contract price, then, under the decisions of the Supreme Court and on principle, the conclusion, in my judgment, must be that by such sale the complainant has exercised its exclusive right to sell, so far as the particular commodity sold is concerned, and cannot legally fix the price at which the dealer shall resell.

This contract does not give the vendee the right to sell. It sells to him the article, and attempts to give him the right to resell. He buys. The manufacturer-patentee sells the product to him, and then seeks to control the price at which he shall resell. If, upon payment by the dealer of the purchase price, the title of the machine passes to him, how can it be taken away because the user, to whom the dealer has sold, has paid a less price than the list price?

The purpose of complainant's contracts with its dealers is to prevent competition between its dealers, each of whom has paid it all it asked. The vice in them is that the patent law does not confer power on the patentee to prevent competition among those who have purchased the patented article from him. I am therefore of opinion that these contracts (the opinion being restrained to the facts in this case) are invalid, and that the defendants in causing them, or attempting to cause them, to be broken, have done the complainant no wrong cognizable by the law." *(Ford Motor Co. v. Union Motor Sales Co., 225 Fed. 373.)*

Violation of Factory Rule with Relation to Machinery

(South Carolina) An overseer of a section of a mill who opens and cleans machinery in motion in violation of a rule of employment forbidding the cleaning of machinery in motion is guilty of negligence as a matter of law, and an employe working under him sustaining injury while at work in cleaning machinery in motion may recover from the employer therefor. *(Newsom v. Poe Mfg. Co., 86 S. E. 195.)*

Proximate Cause of Accident

(Mississippi) Where a lumber company provided a safe contrivance to control its machinery, employed in hauling logs up an incline to its saw shed, and a servant, instead of using such means to stop the machinery, when a belt was slipping off the wheel, placed his foot against the moving belt, a projection on which struck his foot and injured him, the servant's act was the proximate and sole cause of his injury, and the master was not liable. *(Ovett Land & Lumber Co. v. Adams, 69 So. 499.)*

Sale of Stock in Machine Company

(Delaware) Where a corporation owned a patent, and the sole inducement for the purchase of its stock by another corporation was to obtain control of such patent, the buying corporation could have specific performance of the contract for the sale of stock against the seller rather than recovering damages for the failure to perform, since the equitable doctrine of specific performance applies to contracts for the sale of personalty having a unique value, and not generally dealt in on the market, so that money damages will not afford a certain and adequate remedy at law. *(U. S. Fire Apparatus Co. v. G. W. Baker Mach. Co., 95 A. 294.)*

Statement of Salesman Excluded

(South Carolina) Where plaintiff manufacturer of machinery for re-weaving jute bagging gave written warranty upon a sale that its machine would work jute bagging, but not that it would work sugar sacks, in an action for the price, in which the buyers counter-claimed for damages, the action of the court in excluding evidence proving damages from the alleged failure of the machinery to work sugar sacks was proper, since a written warranty cannot be enlarged by parol testimony.

Such was the holding in Smith & Furbush Machine Co. v. Johnston, Supreme Court of South Carolina.

The machine company brought the action to recover $4150, the balance of the purchase price of the machinery sold to Johnston. Johnston denied liability on account of defects in the machinery. He also alleged that the machinery had not come up to warranty. In the trial court an effort was made to introduce in evidence certain verbal statements made by the machine company's salesman at the time the machinery was sold, such statements in effect warranting the use to which the machinery might be put. The judge of the trial court refused to permit the introduction of this evidence saying that the warranty was in writing and incorporated in the contract of sale. The trial court found for the machine company and an appeal was taken to the Supreme Court where the judgment was affirmed. *(Smith & Furbush Machine Co., v. Johnston, 86 S. E. 490.)*

* * *

CONSISTENCY IN WAGE PAYMENTS

Nothing is so vital to the workman as the pay he gets. Working conditions may be bad but if the pay is good he will generally stick, and if he leaves there will be no lack of others competent to fill his place. But let the wages be low, and all the welfare work and comfortable shop facilities will not reconcile him to the fact that he is not adequately compensated in dollars and cents.

The just employer recognizes this simple fact and pays the going rate to ordinary workmen, and higher rates to those more highly skilled and efficient. But when he has done this, has his duty been done to labor in general that makes the things he buys if he invariably buys from the lowest bidder? Emerson wrote that "consistency is the vice of little minds only", and apparently few have little minds if this be a test. One of the largest employers of labor in the metal-working industries has raised the wages of employes far above the going rate, but he screws the prices of the things he buys down to the last notch. In fact, this policy is so well known and notorious that a manufacturer who has secured a large contract from the aforesaid concern is looked on with suspicion by the bankers when he tries to borrow money on the strength of it. The banker knows from experience that the contractor has probably made a losing bargain or one that will net him but little profit.

Is this just to labor? Surely not. The workmen in the contractor's shop must work for low wages or at heart-breaking speed if the contractor makes good. These workmen are entitled to good wages as much as the men in the manufacturer's own plant. How can he make flesh of one and fish of the other?

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MACHINERY

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THE press working of metals is a highly interesting subject and one having many varied developments which by no means have yet reached their climax. New problems are being worked out daily and metal working practice is being changed to a marked degree. The forging of iron and steel in dies has been practiced by blacksmiths from time immemorial, and drop-forging by means of dies in drop hammers has within the last fifty years become a highly important industry. The shaping of sheet metal cold in power presses also has attained much importance, and is another great specialized industry, producing yearly vast numbers of manufactured parts in iron, steel, copper, brass, aluminum and nickel. Coining presses used for the cold impression of coins, medals, transmission chain parts and other pieces produced in large numbers which require embossing or chamfering have an important place in the manufacturing world. The ramifications of press and hammer working presses are many, and a list of all would be extensive. Cold and hot swaging by rotary and vibrating hammers and rivet spinning are more examples of the many that might be cited.

Within the past decade, another application of presses of both the hydraulic and so-called power types has come into use, which up to this time has not been featured prominently in the technical publications. This is the press molding in dies of metal "ingots," both hot and cold. Brass, bronze, copper, aluminum and nickel castings and forgings are compressed and made true to form by being squeezed in dies by special presses of great power. Press molded castings are improved in physical characteristics, minute blow-holes are closed, the roughness inevitable with sand castings is corrected, and in some cases the need of subsequent machining is dispensed with. The possibilities of press molding are apparently limited only by the available sizes and power of presses and strength of the dies. The intensity of pressures produced is very great, often exceeding those developed by the explosion of the powder charge in large guns, and in some cases being over 100,000 pounds to the square inch.

In another part of this number is the first article of importance dealing with the work, dies and machines used in this machine die molding or casting practice. Who can say to what extent this process may displace the typical machine tool operations? Press molding of steel is already being done on a limited scale, and greater developments undoubtedly will be worked out when more highly resistant steels are available for die construction, opening a field for fruitful investigation in determining the laws governing the flow of metals under pressure. Much is yet to be learned about the action of highly refractory metals under great pressure and the forms of dies that favor the greatest displacement with the least pressure.

* * *

A COMMITTEE appointed by the American Society of Mechanical Engineers recently completed a boiler code which probably will rank with the most valuable standardization work accomplished by any engineering society. This code, which represents months of untiring work by men thoroughly familiar with boiler design and the conditions of the trade, is based not merely on theory, but on the common sense of practical men, who took into consideration all the trade as well as technical conditions with which the boiler industry is concerned. Boilers built under this code are already acceptable to the boiler departments of the states of Ohio and Indiana, and to the cities of Detroit and Chicago. The authorities of Pennsylvania, Wisconsin and California have accepted the code, to be put in force later, and a movement is on foot to secure legal adoption by all the other states.

The code has been endorsed by the American Society of Mechanical Engineers, the American Boiler Makers' Association, the National Tubular Boiler Manufacturers' Association, the Master Boiler Makers' Association, the Hartford Steam Boiler Inspection & Insurance Co., Fidelity & Casualty Co., Maryland Casualty Co., London Guarantee & Accident Co., Ltd., National Threshman's Association and the National Electric Light Association.

The legal adoption of the code throughout the United States would undoubtedly result in great benefits to boiler makers and users, making for the preservation of human life and property, and for increased engineering efficiency.

* * *

THE development of toothed gearing and the machinery for cutting gear teeth, is one of the most interesting phases of machine design and construction. The earliest gears were made entirely of wood and were followed in mill construction by mortise gears, that is, cast-iron centers and rims with wood teeth set in mortises cast in the rims. The all-cast gear was made possible by improvements in patternmaking and foundry methods. But no perfection of foundry practice, even machine molding the teeth, resulted in producing gears with the accuracy of pitch and tooth contours required for smooth and even power transmission. Helical gears used in rolling mills were cast with all the care possible, and while superior to cast spur gears were still short of the perfection sought.

Some years ago it was realized that gears of the largest size should have machine cut teeth; but the difficulties of accurately cutting steel gears of three or four feet face and twelve or fifteen feet diameter, especially helical gears, were enormous. The development of hobbing machines for cutting spur and spiral gears of common dimensions opened the way for successful machines, capable of handling the largest gears used in steel mills. The progress of the hobbing cutter across the face is not localized between two adjacent teeth, but takes place comparatively slowly as the hob traverses the entire periphery. Thus the evil effects of heating and consequent distortion of the blank and cutter are minimized.

The great hobbing machine described in this number is believed to be the largest machine of this type yet built. It is interesting not only because of its unique features, but also because it marks another forward step in the perfection of heavy machinery. The millwright's limits are no longer the smaller divisions of a carpenter's two-foot rule—he requires the transit and other instruments of precision when massive cut gears are erected. A watch movement is no more accurately made, comparatively speaking, than the best rolling machinery now provided for the modern steel works.

WEIGHING-SCALES

PRINCIPLES OF OPERATION OF THE COMMON TYPES OF SCALES AND METHODS OF INSPECTING AND TESTING

BY F. J. SCHLINK*

F. J. Schlink †

THE operation of weighing is so familiar to those in the engineering trades and professions that very few give any thought to the process itself or to the principles involved. As a matter of fact, however, the accurate determination of the weights of commodities involves considerations of considerable complexity. Most people have a false impression of the accuracy which is attained in ordinary commercial weighing; the belief seems to be very common that any sort of apparatus is good enough for this work, and that the most perfunctory care or no care at all is sufficient to keep it in serviceable condition. Work recently done by the Bureau of Standards in the inspection and testing of weighing-scales has illustrated very forcibly the need of improvements in the methods of design and manufacture, of better care of weighing-scales in service, of a systematic provision for their regular test, and of the supervision of the conditions of their use.

Frequently scales are found whose condition is such as to make their use in the highest degree inadvisable for any sort of weighing; they may even be inaccurate to the extent of 10 per cent or more, while inaccuracies of 3 to 5 per cent are not at all infrequent. Yet such scales are often used for the weighing of high-priced commodities and the weights obtained are made the basis of purchase or sale. Even new scales are often unsatisfactory and inaccurate, whether on account of defects of design or manufacture, or what is perhaps more common, improper installation. A general knowledge of the principles of operation of the various types of scales in common use, and of the proper methods of their inspection and testing is a desirable acquisition for any man whose duties bring him into close relation with such apparatus. It is the purpose of this article to outline these principles in such a manner as to make them of service to the engineer and the mechanic.

Types of Weighing-scales

Let us first note briefly the types of weighing-scales in common use in the mechanical industries. The first is the precision balance, used in chemical and metallurgical laboratories, and wherever the weight of small quantities must be determined to a high degree of precision. Such balances are usually of the equal-arm type, with pans hung below the beam and carried on knife-edges of agate or hardened steel. The use of such balances requires a high degree of skill and care, and is usually confined to the laboratory, where the requisite freedom from vibration and other disturbing factors can be maintained.

Where large quantities are to be weighed and the character of the work is such that great precision is not needed, platform scales are commonly used. Most of the scales used in shops and industrial establishments are of this sort. Under platform scales may be classed the portable platform scale, adapted to be moved from place to place, the large so-called dormant scale used in warehouses and factories for weighing heavy crates and trucks, the wagon or auto truck scale, for weighing loaded horse-drawn or motor-driven vehicles and the track scale, used for weighing railway cars, either as the basis of purchase or sale of a commodity, or for the determination of the charge to be made for transportation.

In addition to those named, there are a few other types of scales in common use. Among these may be named the crane scale, used for weighing loads while they are suspended from a crane, the dynamometer, for the measurement of the power output of a prime mover, or for the determination of the tractive force required to move a car or truck, and the materials testing machine, which is used to determine the breaking strength and elastic properties of structural and other materials.

Construction of Platform Scales and Causes of Inaccuracy

Fig. 1 shows in diagrammatic form the construction of a common type of platform scale, giving the names which are commonly applied to the various parts. The small triangles are the knife-edges, and the cross-hatched parts indicate members which are affixed immovably to the frame of the scale. In order that the weight indication may be independent of the position of the load on the platform, the following relation must apply:

$$\frac{a_1}{c_1} = \frac{a_2}{b_2} \qquad (1)$$

The leverage ratio R, or multiplication of the scale, is defined by the equation:

$$R = \frac{b_2}{a_2} \times \frac{c_2}{a_2} \qquad (2)$$

The amount of weight required on the counterpoise pan to balance a given load on the platform is found by dividing the platform load by this ratio R. In order that this multiplication may be a definite and unchanging quantity, the knife-edges must be affixed to the lever and not to the connecting element; they must be sharp, and hard enough so as not to flatten appreciably under the loads which they are to carry; and the knife-edges in any lever must be parallel to each other. The knife-edges in any lever should lie approximately in a single plane, for reasons which will appear later. The planes through the bearing lines of the knife-edges belonging to the several levers must be parallel to one another, and the same is to be said of the loops and rods which connect the levers to each other. In practice, the levers are usually arranged so as to lie with the plane of the knife-edges horizontal and the lines of the connections vertical.

These are points which are not well understood. In adjusting the distance between the knife-edges, the manufacturer uses standard weights which are hung from the knife-edges, the lever and the attached weights being mounted so as to swing freely as a simple balance. The forces acting on these knife-edges, then, are in the direction of gravity, that is, vertical, and the parts of the scale when installed must be so placed that the same direction of the forces will obtain. If this is not the case, the lever arms of these forces will not be the same as they were at the time the adjustment was made, and the scale will be incorrect.

These relations will be easily understood from Fig. 2. Suppose that the lever shown here was so adjusted that the ratio of its arms was 4 to 1; this relation having been obtained by hanging weights of, say, 10 and 40 pounds, respectively, from the two end knife-edges, and then altering the distances a and b by shifting the knife-edges or by grinding back their faces so that the lever balance so formed came to a condition of equilibrium. If now this lever were set up in a scale in such a manner that the loops connecting its knife-edges to those of another lever were not vertical but inclined, as indicated by the dotted lines in the figure, the ratio would no longer be $a:b$, but another value which would be defined as $R = \frac{a \cos \alpha}{b \cos \beta}$. The force relations which were intended to prevail would no longer exist, and the scale would be incorrect, the amount of this inaccuracy depending, as shown by the equation just

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given, upon the lengths of the lever arms, and the degree of inclination of the two connecting-rods to the plane defined by the knife-edges in the lever.

Sensibility of a Scale

The quality of accuracy in a scale is not alone sufficient to insure its suitability for a given purpose. It must also have a proper sensibility. The sensibility of a scale or of any engineering instrument is its ability to respond to small variations in the quantity which it is to measure. It is usually expressed in terms of the distance or angle traversed by the pointer or other reading or indicating device for a unit change in the quantity being measured.

In a weighing-scale it is found convenient and advantageous for a number of reasons to invert the ratio and use the term "sensibility reciprocal." The following definition of this quantity has been adopted at the tenth annual conference on the weights and measures of the United States: The term "sensibility reciprocal" is defined as the weight required to move the position of equilibrium of the beam, pan, pointer, or other indicating device of the scale a definite amount at the capacity or at any lesser load, the effect of friction in causing inconstancy of this position of equilibrium being eliminated.

A platform scale, as illustrated in Fig. 1, is usually provided with a loop at the end of the beam, or other means to limit the motion of the beam to a suitable and convenient amount. Therefore in the case of platform scales the sensibility reciprocal is defined as follows: In scales provided with a beam and trig-loop the sensibility reciprocal is the weight required to be placed upon the platform to turn the beam from a horizontal position of equilibrium in the middle of the trig-loop to a position of equilibrium at the top of the loop. The sensibility reciprocal may be determined by subtracting the weight instead of adding it, thereby causing the beam to assume a position of equilibrium at the bottom of the loop; or indirectly, by moving the sliding poise on the beam the required amount in either direction, to obtain the specified change in the position of equilibrium of the beam; or by adding or subtracting small weights to or from the counterpoise until the specified change is obtained, and determining the equivalent of the small weights used, in terms of weight on the platform.

Distinction between Sensibility and Accuracy

The sensibility and accuracy of scales are often confused, for the user is likely to assume that a scale which responds readily to slight changes of load is an accurate scale. The sensibility of a scale is not directly a measure of its accuracy. It indicates only to what degree of precision readings may be

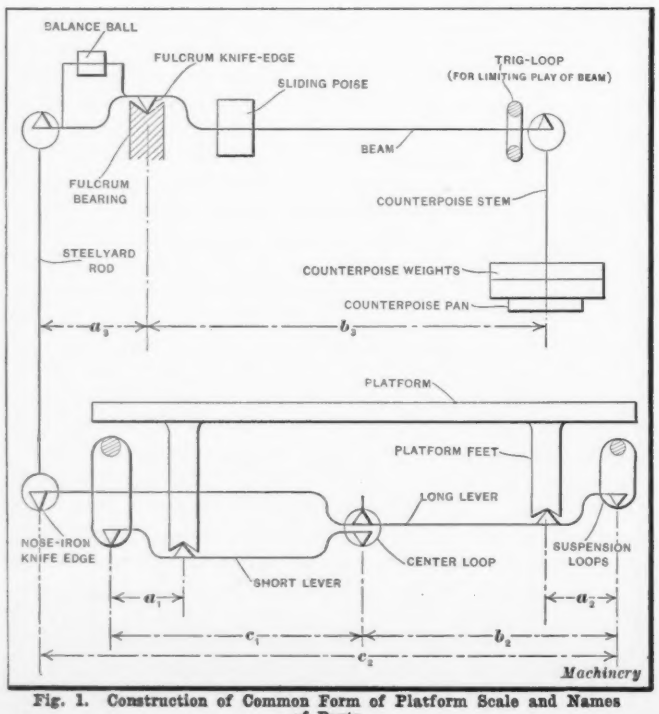


Fig. 1. Construction of Common Form of Platform Scale and Names of Parts

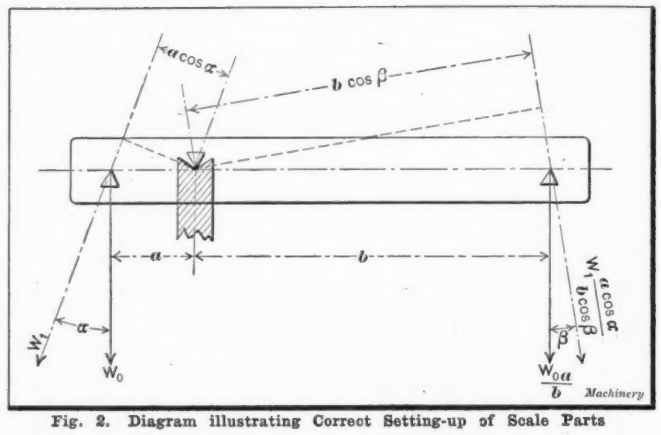


Fig. 2. Diagram illustrating Correct Setting-up of Scale Parts

taken, provided proper allowance be made for the error or correction of the scale at that reading, the effect of friction being considered eliminated.

The factors which determine the sensibility of a platform scale or of any scale in which the reading is obtained through the operation of a lever system oscillating about a definite position of equilibrium, are given by a complex expression which it will be of little service to develop here. It may be said, however, that within certain limitations, the sensibility, which in practice is controlled by adjustment of the beam of a scale, increases with: (1) increasing length of beam; (2) decreasing weight of beam; (3) decrease of distance at which center of gravity of beam lies below its center or fulcrum knife-edge; (4) decrease of multiplication or leverage ratio of scale.

Determination of Indications of Scales

The indications of a platform scale are obtained as a rule in either one of two ways or by a combination of the two. The first method, and the one allowing the higher accuracy consists in the use of counterpoise weights which are placed upon the counterpoise pan in sufficient amount to bring the scale to a balance under the applied load.

The second method consists in employing a sliding or traveling weight which is adapted to be moved along the beam until the effective lever arm upon which the poise acts is sufficient to bring the scale to balance. In many of the commoner types of scales these two methods are used in combination, the sliding poise being used for the determination of the weight in the intervals between the values represented by the counterpoise weights. In many of the later designs, especially those of large capacity, sliding poises alone are used, as by this means the handling of loose weights and the attendant possibility of errors in totaling are eliminated, and besides the speed of weighing is materially increased.

In order that the graduations on the beam may not be too closely spaced for convenient reading, the principal poise is often constructed so as to be set accurately in position by engagement with notches in the beam, and is provided with a secondary and smaller poise or a bar moving within its body, this secondary poise being used for estimation of the values between those represented by the notches on the beam.

Relation of Fineness of Graduation to Sensitiveness of Scale

The sensitiveness of a scale should be properly correlated to its probable accuracy and the fineness of its graduation. In the case of platform scales, the sensibility reciprocal should not be greater than the value represented by two of the minimum graduations upon the beam. This relation is based upon the assumption that the reading of the scale cannot be estimated more closely than one-half of the sensibility reciprocal, as this corresponds to about the smallest motion of the beam in the trig-loop which may be discernible with certainty in ordinary use. One might be inclined to ask why a scale should not be made as sensitive as possible, in order that the utmost precision of reading could be secured. The obtaining of a very high sensitiveness is fraught with numerous practical difficulties. The least wear occurring in a scale will change the position of the center of gravity of the levers in relation to their centers of rotation, so that a scale always tends to become less and less sensitive with use. Further-

more, a high sensibility is always accompanied by a slowness of action, that is, a long period of oscillation of the beam, increasing the time consumed in weighing. In the case of platform scales for industrial use the precision of reading and the fineness of graduation necessary for a given purpose should be determined by experience or the special needs of the case, and the scale then adjusted to have a sensibility reciprocal to correspond.

Testing Scales

The test of a weighing-scale is ordinarily made with standard weights; loads are applied at the nominal or rated capacity and at several fractions of the capacity, and the indications of the scale compared with the known load. The errors of a scale vary somewhat from time to time, and according to the position of the load on the platform, so that it is as a rule impracticable to determine the errors of a scale once for all. For this reason, the commercial and routine test of a scale is usually a tolerance test, that is, the test is made, and the scale adjusted, if necessary, so that the errors are within certain small predetermined values, chosen by experience and properly suited to the general uses to which the scale is put and the conditions of its service. These values are called tolerances, and are given for platform scales in Table I.

Tolerances

The tolerances to be allowed in excess or deficiency on all platform scales, except counter platform scales, shall not be greater than the values given in Table I; provided, however, that the manufacturers' tolerances or the tolerances on all new platform scales, except counter platform scales, shall not be greater than one-half of the values given; and provided further, that these tolerances on all these platform scales, shall in no case be less than the value of one of the minimum graduations on the beam except that the manufacturers' tolerances or the tolerances on new apparatus shall in no case be less than the value of one-half of one of the minimum graduations on the beam. The maximum sensibility reciprocal allowable on all platform scales, except counter platform scales, shall not exceed the value of two of the minimum graduations on the beam, at the capacity of the scale or at any lesser load. Provided, however, that the manufacturers' maximum sensibility reciprocal or the maximum sensibility reciprocal on all new platform scales, except counter platform scales, shall not exceed the value of one of the minimum graduations on the beam at the capacity or at any lesser load.

The test of a scale is usually performed at its capacity load, if practicable to apply weights to that amount; at one-half of the capacity or less, with the load concentrated at prescribed points upon the platform; and at certain loads determined by the maximum reading of the several bars of the beam, or of the reading face. A detailed outline of such a test will be given hereafter.

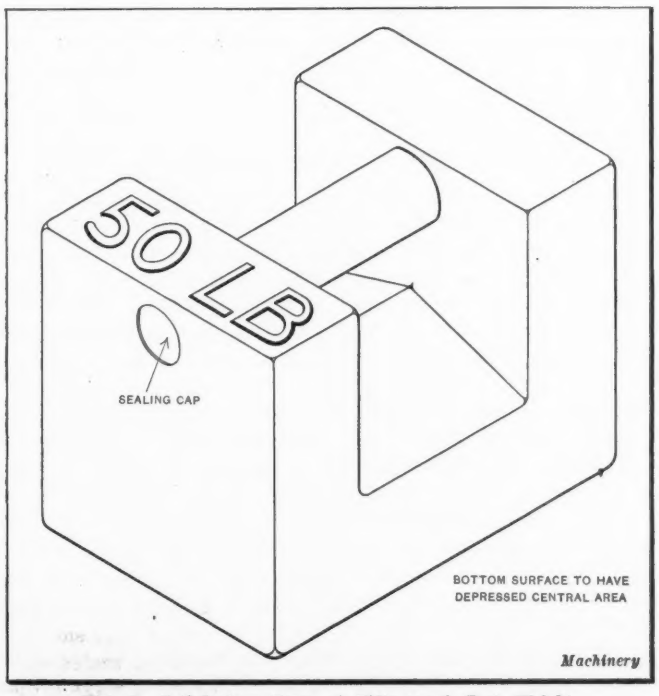


Fig. 3. Satisfactory Form of Fifty-pound Test Weight

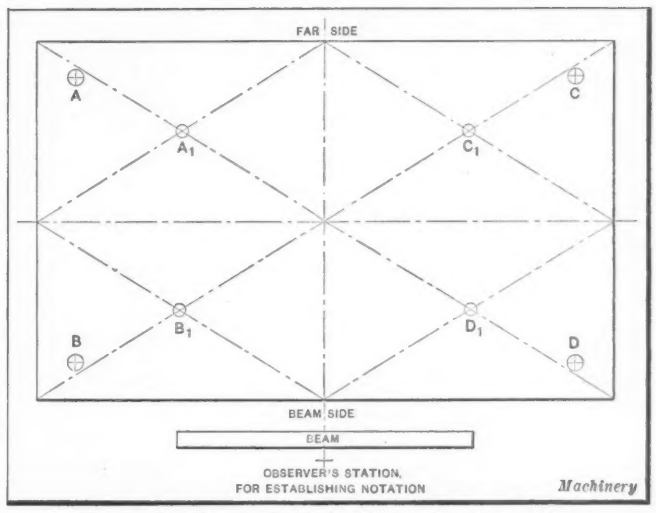


Fig. 4. Notation for Load Positions on Platform Scales

Test Weights

The test weights used are made in various denominations and forms, but for making up the platform load used in the test of a platform scale, fifty-pound test weights are most useful. These weights should be accurately adjusted in conformity with the national standards of the country. Their adjustment can only be maintained by protecting them from abuse or misuse, and by occasionally checking them up against standards of known constancy and accuracy. Fig. 3 shows a common and satisfactory form of fifty-pound test weight, made of cast iron and well adapted to the testing of platform scales. The weight is provided with a cavity as indicated, in which lead or other material is added to bring it accurately to its value. This cavity is closed with a screw, over the head of which is placed a seal of lead or aluminum, which secures the adjusting material from unauthorized or careless alteration. Cast-iron weights change in value slightly from time to time on account of changes going on within the mass, due to atmospheric and other causes, and the wear and abrasion common to all weights affect these also. They must therefore be checked at regular intervals against standards of higher constancy. For weights of higher grade, used as reference standards, brass, protected by a coating of lacquer or gold-plating, is commonly used.

Inspection of Parts of Platform Scale

In the following will be taken up briefly the mode of inspection and test of a platform scale. The test of a scale should invariably be preceded by a thorough inspection of its parts. The knife-edges and bearings should be carefully examined for the presence of rust and dirt. If the knife-edges are badly flattened from rust or wear, or if the operating parts are jammed with dirt and foreign material, the test should not be carried out until the parts are set aright. Knife-edges which are rusty and worn should be replaced and refinished by a competent scale mechanic.

The moving or "live" parts of a scale must not touch or rub against parts of the rigid structure. Loops and connecting-links should be plumb. Care should be taken to see that knife-edges are properly centered on their bearings. The check-rods, which retain the platform in position on its knife-edges against the action of the jar and impact due to the application of the loads being weighed, should fit loosely on their pins or other supports, and should lie in a horizontal plane. If any are broken, they should be replaced.

In connection with the question of rust and corrosion of scale parts, it cannot be too strongly urged that every care be taken to keep scale pits clean and dry. If the scale is exposed to the weather, provision should be made for the drainage of the pit. If the pit can be ventilated as well, the deposition of moisture on the parts will be reduced, as will also the tendency to rust.

Detailed Test of a Platform Scale

The first step in the test of a scale is to put it in a condition of balance at zero load. This can be accomplished by setting all the sliding poises at their zero marks, removing all loose counterpoise weights and then moving the balance ball provided for the purpose of balancing, or by adding or removing shot from the counterpoise pan, which, when provided, is usually made hollow for this purpose.

Next apply to the center of the platform, test weights about equal in value to one-quarter of the scale capacity. Take a reading of the scale, using standard counterpoise weights if the scale is not provided with a full-capacity beam. If all the readings of the scale are taken with the sliding poise, advance this poise and any auxiliary poises, as may be necessary, until a balance is obtained. Note the reading. Then determine the sensibility reciprocal as indicated in the definitions above.

Now move the test weights, in turn, to each of the four corners of the platform, locating the center of gravity of the stack of weights directly over the principal platform bearings *A*, *B*, *C*, and *D* as denoted in Fig. 4. Note the readings in each case. In case the platform bearings of the scale are so close to the corners of the platform that it is impracticable to place the weights as just described, test weights amounting to one-half the capacity of the scale or more may be placed with their center of gravity, in turn, at the centers of the rectangles denoted in Fig. 4 by A_1, B_1, C_1, and D_1.

Next test the scale at its full capacity, if sufficient test weights are at hand. Determine the sensibility reciprocal at this load also. If the beam has one or more sliding poises moving on individual bars, these should each be tested at their maximum graduation. The remaining graduations should be uniformly spaced, for equal increments of reading, and, in practice, this will usually be found to be the case. The errors of the scale which have been determined should be compared with Table I. If they exceed the values given in this table, the scale is incorrect and should be adjusted.

It has been assumed that the test of the scale has been conducted with standard counterpoise weights if any were used, that is, counterpoise weights having errors within a known small tolerance. If standard counterpoise weights are not at hand, those furnished with the scale may be used for the purpose of test, but their errors must be determined, and the actual values of the individual weights used in computing the errors of the scale. The counterpoise weights may be tested on a sensitive balance of the equal-arm, suspended-pan type. Such balances are made up in portable form especially for use in weights and measures inspection work, inspector's kits usually including also a set of standard weights. After determining the errors of the counterpoise weights, they should be compared with Table II, which gives the tolerances on weights used with multiplying lever scales, for various multiplications.

TABLE I. TOLERANCES FOR PLATFORM SCALES

Load in Pounds	Class A		Class B	
	Tolerance		Tolerance	
	On Ratio in Ounces	On Beam in Ounces	On Ratio in Pounds	On Beam in Pounds
50	$\frac{1}{2}$	1	...	...
100	1	2	...	...
200	2	4	...	...
240	3	6	...	...
300	3	6	...	...
400	4	8	...	...
500	5	10	$\frac{5}{8}$	$1\frac{1}{4}$
600	6	12	$\frac{3}{4}$	$1\frac{1}{2}$
		Pounds		
800	8	1	1	2
1000	8	1	1	2
1200	10	$1\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{1}{2}$
1500	12	$1\frac{1}{2}$	$1\frac{1}{2}$	3
1800	14	$1\frac{3}{4}$	$1\frac{3}{4}$	$3\frac{1}{2}$
Tons	Pounds			
1	1	2	2	4
$1\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{1}{2}$	5
2	2	4	4	8
3	3	6	6	12
4	4	8	8	16
5	5	10	10	20
6	6	12	12	24
8	8	16	16	32
10	10	20	20	40
12	12	24	24	48
15	15	30	30	60
20	20	40	40	80
40	40	80	80	160
50	50	100	100	200
80	80	160	160	320
100	100	200	200	400
150	150	300	300	600
200	200	400	400	800

Machinery

"Class A" scales include the following: scales of the portable platform type; and also scales of the dormant type which are installed inside a building having side walls and roof, which protect the scale from weather effects and from sudden changes of temperature.

"Class B" scales include the following: scales of the railroad track and wagon types, and also scales of the dormant type which are not installed inside a building having side walls and roof, and which are exposed to weather effects and sudden changes of temperature. The latter effect, since it causes the condensation of moisture on the scale parts, often has as serious results on the condition of the scale as have weather effects.

The columns with the heading "Tolerance on Ratio" refer to the error in the ratio or multiplying power of scales with which counterpoise weights are used.

The columns with the heading "Tolerance on Beam" refer to those parts of scales not requiring the use of removable weights, for example, a beam.

The column with the heading "Load" refers to the amount of weight on the platform of the scale.

TABLE II. TOLERANCES FOR COUNTERPOISE WEIGHTS FOR MULTIPLYING LEVER SCALES

The tolerances to be allowed in excess or deficiency on commercial weights shall not be greater than the following values: Provided, however, that the manufacturers' tolerances or the tolerances to be allowed on new commercial weights shall not be greater than one-half of the values given.

Weight	Ordinary Weights (Ratio 1: 1)	Ratio less than 100: 1	Ratio 100: 1, and less than 1000: 1	Ratio 1000: 1 and over
Pounds	Grains	Grains	Grains	Grains
50	100.0	60.0	40.0	20.0
25	60.0	36.0	24.0	12.0
20	60.0	36.0	24.0	12.0
15	40.0	24.0	16.0	8.0
10	40.0	24.0	16.0	8.0
8	30.0	18.0	12.0	6.0
5	30.0	18.0	12.0	6.0
4	20.0	12.0	8.0	4.0
3	20.0	12.0	8.0	4.0
2	15.0	9.0	6.0	3.0
1	10.0	6.0	4.0	2.0
Ounces				
10	10.0	6.0	4.0	2.0
8	5.0	3.0	2.0	1.0
5	5.0	3.0	2.0	1.0
4	5.0	3.0	2.0	1.0
2	3.0	1.8	1.2	0.6
1	2.0	1.2	0.8	0.4
$\frac{1}{2}$	2.0	1.2	0.8	0.4
$\frac{1}{4}$	1.0	0.6	0.4	0.2
$\frac{1}{8}$	0.5	0.3	0.2	0.1
$\frac{1}{16}$	0.5	0.3	0.2	0.1
$\frac{1}{32}$	0.5	0.3	0.2	0.1
$\frac{1}{64}$	0.2	0.12	0.08	0.04
Ratio of Tolerances	$\frac{4}{5}$	$\frac{3}{5}$	$\frac{2}{5}$	$\frac{1}{5}$

Machinery

Establishment of Inspection System

Every industrial plant should provide in some manner for the regular test and inspection of all the scales which it uses. A record should be kept of the date of their installation, their cost, the dates on which inspections, tests, repairs, and adjustments are made, and the cost of all repairs and replacements of parts. The accompanying chart shows a form which has been found convenient for recording the test data. It will be found to cover most of the points which are to be noted and recorded and may, of course, be modified to meet special needs.

This work should be under the responsible charge of one competent man, who should inform himself as to the methods and equipment necessary. He should supervise the weighing methods used throughout the plant, should be made individually responsible for the maintenance, care, and adjustment of all test weights and scale-testing equipment, and should see that every scale in use in the plant is at all times kept within the required accuracy and in good repair. He should be familiar with the various kinds and types of scales on the market, in order that he may be in position to make proper recom-

mendations when the purchase of new scales is contemplated. He should further satisfy himself that every new scale purchased complies fully with approved tolerances and specifications. It is certain that when the importance of the weighing operation is better appreciated, such an organization will be adopted in every large plant where the services of a competent weights and measures official (state, county, or city sealer) are not readily available.

If a sealer properly equipped for the work is at hand, who regularly inspects and tests the scales in a plant, the manufacturer should cooperate with him as fully as possible. Money expended in securing correct weights is money well invested.

Cooperation of Bureau of Standards with Manufacturer on Weights and Measures Problems

The Bureau of Standards has accumulated a large experience in the design, testing and inspection of weighing-scales of every sort, from the small eight-ounce capacity letter scale used in the postal service to the three hundred thousand-pound capacity railroad track scales used in the weighing of carload shipments of commodities. This bureau is always ready to lend every possible assistance to the manufacturer in solving weights and measures problems.

The tolerances and specifications for weights and measures and weighing and measuring devices, as adopted at the tenth annual conference on weights and measures of the United States, are issued as a publication of this bureau and may be obtained upon application. In addition, there are also available Circular 47, giving definitions and tables of equivalents of the units of weight and measure, and a special publication entitled "The International Metric System of Weights and Measures." Several publications of interest on the testing and inspection of scales are at present in preparation.

SECRETIVENESS IN THE BRASS INDUSTRY

Old Home Week was celebrated in Waterbury, Conn., in the latter part of November and naturally a spirit of hospitality pervaded the famous home of brass working industries. Some good souls evidently feared that this warm glow might cause some indiscreet manufacturers to admit visitors to their plants and disclose to strangers secrets that have been carefully preserved lo! these many years. The *Waterbury American* offered the following cautionary advice in an editorial in the November 23rd number:

> A good part of Waterbury's industrial efficiency lies in the machinery its men of mechanical genius have invented and made to produce the goods it manufactures and sells. We are proud to have others notice this efficiency and the ways and means by which we accomplish it. But if they learn how we do it, and obtain from us the machinery by which it is done they will be able to make the goods we now sell to them. They will be aided also by cheaper labor and nearness to the market. Let us not be inhospitable—nor give ourselves away.

Secretiveness is characteristic of the brass working industry generally. The average proprietor of a brass shop is a hermit as regards visiting competitors or allowing them to visit him and exchange ideas. It would be interesting to trace this extreme conservatism to its source and to ascertain the reasons why secretiveness in the industry so generally persists. There can be few good reasons for it. Are not there hundreds of brass manufacturers, all prospering and all probably using many of the same methods, kinks and devices for facilitating manufacturing? It must be so. Otherwise how could they successfully compete? Secretiveness has become a tradition—a policy to be preserved when the chief reasons for it long ago disappeared.

SCALE TEST AND INSPECTION RECORD

Place.....Owner.....Manufacturer.....

Scale Number.....Designation.....Test Number.....Page.....Inspector..... Date.....

Observation Number	Value of Load	Position of Load	Counterpoise Weight at End of Beam*	Sliding Poise Reading	Balance†	Total Reading‡	Sensibility Reciprocal	Error of Scale¶	Remarks

TEST OF COUNTERPOISE WEIGHTS

Denomination		Distinguishing Mark	Error	Tolerance Allowable	Within or Without the Tolerance	Remarks
Equivalent	Actual					
		(If several weights of one denomination give them distinguishing marks)				

Type of Scale	Date Installed	Information relating to previous tests, inspection, repairs and adjustments	
Capacity of Scale, Nominal.....		Condition of Parts.	Of Other Parts.
On Sliding Poise.....		Office	
On Counterpoise Weights.....		Poise Weights.....	
Size of Platform.....		Knife-edges	
Material Weighed		Bearings	
Length of Beam, Fulcrum to Trig-loop.....		Checks	
Play in Trig-loop.....		Levers	
If Notched Beam——Notches in——inches.....		Pit	
Multiplication of Scale		Foundations	
.....		Drainage provision.	

Machinery

* Record actual value, not equivalent value.

† Record check mark if normal center balance and the words "high" or "low" if extreme balance is used for determining sensibility reciprocal.

‡ The fourth column value multiplied by nominal multiplication of scale, to which is added the fifth column value.

¶ Total reading minus value of test load.

Making Cartridge Cases on Bulldozers and Planers

Douglas T. Hamilton

THE manufacture of cartridge cases described in the December number of MACHINERY is carried on by means of power presses of the crank and flywheel type, but many manufacturers who had orders for this work could not get deliveries on machines of this type and consequently had to resort to other methods of handling the work. The amount of ingenuity shown in this direction is remarkable. One good example of the application of car-shop equipment to this work is described in the following. All the cupping, redrawing and tapering operations are accomplished on bulldozers and frog and switch planers which have been fitted up for doing this work. The only special machine that had to be purchased to complete the cartridge case, with the exception of the machining operations, was a hydraulic heading press. The order of cupping and redrawing operations is shown in Fig. 3, and also in the accompanying table, which includes all the data—machines used, production, scleroscope readings, etc.

Cupping

In the plant where this information was obtained the blank is obtained of the correct size and thickness, and in the annealed condition. The first operation, therefore, is cupping, as shown in Fig. 1 and at *A* in Fig. 3. For this work, a Niles-Bement-Pond bulldozer is used. The die is held on the crosshead and the punch on a fixture attached to the bed of the machine.

This particular machine is fitted up for accomplishing both the cupping and first redrawing operations, the punch shown at *A* performing the cupping and that at *B* the first redrawing. In this way, two men can operate the machine and thus turn out a cup and perform the first redrawing operation at each stroke of the machine. A lubricant known as "Viscosity" and made by the Cataract Refining Co. is used for lubricating the die and punch.

Annealing

Following the cupping operation, the cases are annealed in a Quigley oil furnace as shown in Fig. 2. The cases are held in a sheet iron pan having a wire bottom and are brought to the furnace on a truck as shown, the platform of which is provided with rollers. As soon as the pan carrying the cases is brought in line with the door of the furnace, the air jack shown is operated, forcing the pan into the furnace. The door is then closed and the cases annealed. This furnace is kept at a constant temperature of between 1100 and 1140 degrees F. and holds seven boxes, each box carrying 140 cases. It requires thirty-five minutes for one lot of cases to

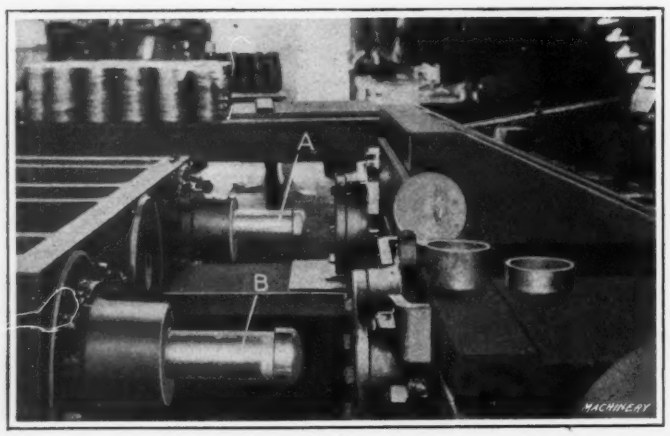


Fig. 1. Performing Cupping and First Redrawing Operations on a Niles-Bement-Pond Bulldozer

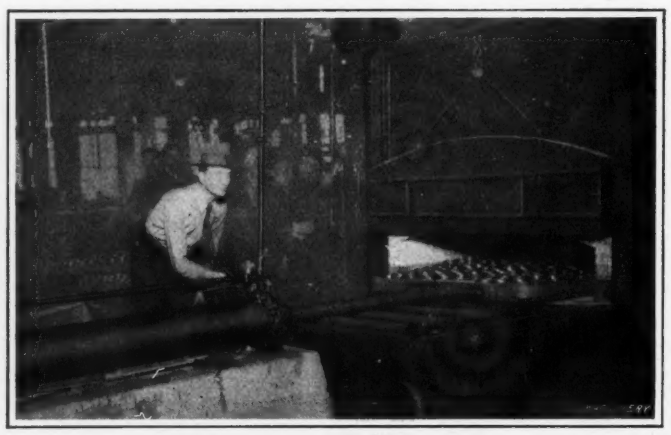


Fig. 2. Annealing Cartridge Cases in a Quigley Oil Furnace for Thirty-five Minutes

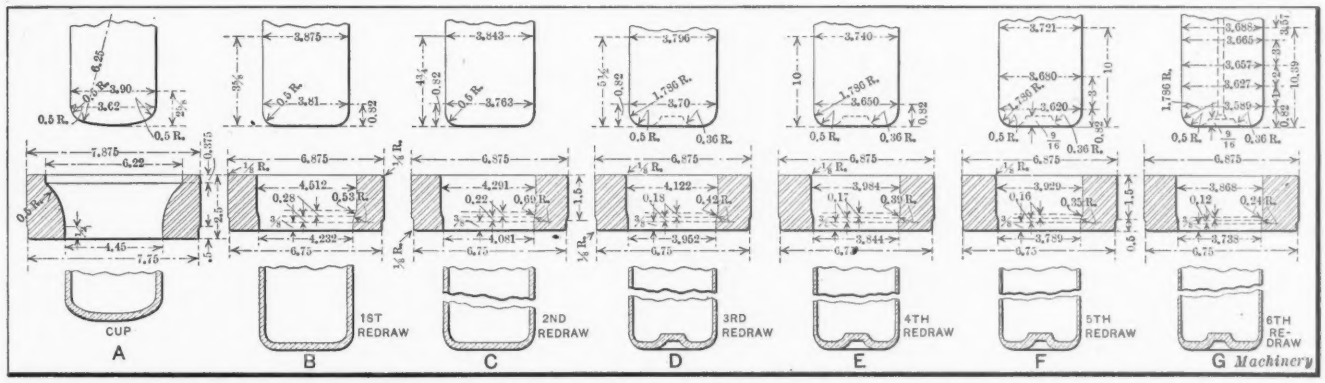
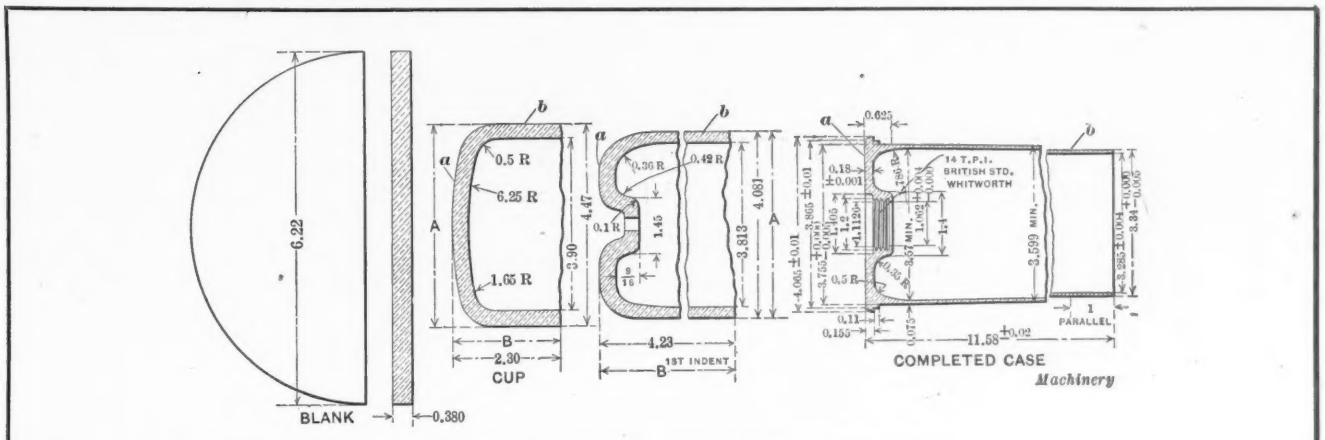


Fig. 3. Punches and Dies used and Sequence of Operations followed in producing British 18-pound Cartridge Cases on Frog and Switch Planers

pass completely through the furnace, so that one box is taken out and one put in the furnace every five minutes. As the pan of cases is removed from the unloading end of the furnace, see Fig. 4, it slides on a platform operated by an air jack in a similar manner to an elevator. This arrangement is located over a cooling bath and is operated to immerse the cases in the cooling bath. When cool, the platform raises the pan of cases, which is then rolled out onto the truck and carried over to the pickling bath shown to the right of the illustration. Here the pan is again picked up by an air jack

DRAWING, HEADING AND MACHINING OPERATIONS ON 18-POUND BRITISH CARTRIDGE CASE



No. of Operation	Character of Operation	A Inches	B Inches	Machine Used	Lubricant	Furnace Used	Temperature of Furnace, Degrees F.	Bath	Scleroscope Reading	Production Per Hr.
1	Blanking	.....	.....	Punch Press	.....	.....	.....	.....	15	....
2	Cupping	4.45	2.30	Bulldozer	Viscosity	.....	.....	.....	*a*, 15; *b*, 50	300
3	Annealing for 35 Minutes	.....	.....	.....	.....	Oil Furnace	1100 to 1140	Water Cooling Acid Wash	15	300
4	1st Redrawing	4.232	3.45	Bulldozer	Viscosity	.....	.....	.....	*a*, 15; *b*, 50	300
5	Annealing for 35 Minutes	.....	.....	.....	.....	Oil Furnace	1100 to 1140	Water Cooling Acid Wash	15	300
6	2nd Redrawing	4.081	4.6	Bulldozer	Viscosity	.....	.....	.....	*a*, 40; *b*, 45	300
7	Annealing for 35 Minutes	.....	.....	.....	.....	Oil Furnace	1100 to 1140	Water Cooling Acid Wash	15	300
8	1st Indenting	4.081	4.23	Bulldozer	Viscosity	.....	.....	.....	*a*, 18; *b*, 15	300
9	3rd Redrawing	3.952	6.25	Bulldozer	Viscosity	.....	.....	.....	*a*, 18, *b*, 45	300
10	Annealing for 35 Minutes	.....	.....	.....	.....	Oil Furnace	1100 to 1140	Water Cooling Acid Wash	*a*, 13; *b*, 15	300
11	4th Redrawing	3.844	7	Bulldozer	Viscosity	.....	.....	.....	*a*, 35; *b*, 45	300
12	Annealing for 35 Minutes	.....	.....	.....	.....	Oil Furnace	1100 to 1140	Water Cooling Acid Wash	15	300
13	2nd Indenting	3.844	6.875	Bulldozer	Viscosity	.....	.....	.....	*a*, 18; *b*, 15	300
14	Drill Hole in Primer Pocket	.....	.....	Vertical Drilling Machine	.....	.....	.....	.....	.....	175
15	Trimming and Burring	3.844	6.25	Toledo Trimmer	.....	.....	.....	.....	.....	200
16	5th Redrawing	3.789	9.75	Frog and Switch Planer	Vaseline	.....	.....	.....	*a*, 20; b, 40	180
17	Annealing for 35 Minutes	.....	.....	.....	.....	Oil Furnace	1100 to 1140	Water Cooling Acid Wash	*a*, 20; *b*, 16	300
18	6th Redrawing	3.738	13.35	Frog and Switch Planer	Vaseline	.....	.....	.....	*a*, 20; *b*, 45	180
19	Trimming	3.738	11.875	Toledo Trimmer	.....	.....	.....	.....	.....	200
20	Heading	3.738	11.750	350 ton, C.P.R. Hydr. Press	.....	.....	.....	.....	*a*, 40 to 50; *b*, 50	100
21	Annealing Mouth for 35 Seconds	.....	.....	.....	.....	Oil Burner	800	Cool in Air	*a*, 40 to 50; *b*, 25 to 35	180
22	1st Tapering	3.347	11.875	Bulldozer	Dry	.....	.....	.....	*a*, 40 to 50; *b*, 35 to 40	300
23	2nd Tapering	3.328	11.95	Bulldozer	Dry	.....	.....	.....	*a*, 40 to 50; *b*, 35 to 45	300
24	Machining Mouth and Head	.....	.....	Bullard Case Machine	Mystic	.....	.....	.....	.....	40
25	Hand Tapping	.....	.....	Bench Fixture	.....	.....	.....	.....	.....	80
26	Reaming	.....	.....	Bench Fixture	.....	.....	.....	.....	.....	80
27	Inspecting	.....	.....	Various Gages	.....	.....	.....	.....	.....	80
28	Stamping	.....	.....	.....	.....	.....	.....	.....	.....	80

Machinery

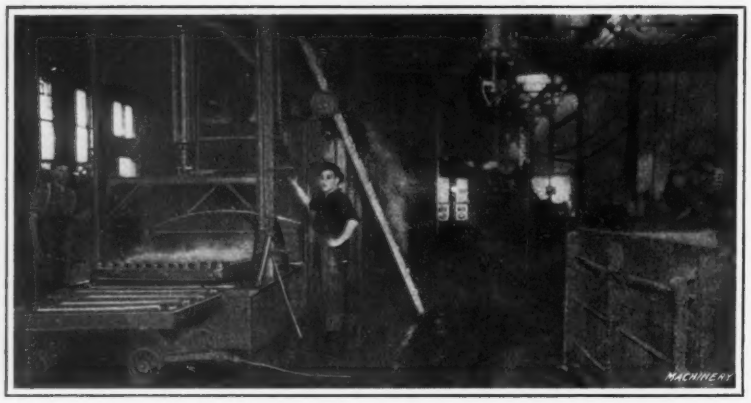


Fig. 4. Immersing Cases in Cooling and Pickling Baths following Annealing

and dipped in the weak sulphuric acid solution used in removing the scale. Following this, the cases are immersed in a hot-water solution.

First, Second and Third Redrawing and Indenting Operations

After annealing and washing, the cases are taken back to the Niles-Bement-Pond bulldozer shown in Fig. 1, and the first redrawing operation is performed as previously described. They are again annealed, washed, etc. Following this, the second redrawing operation is performed. This operation is handled on a Williams & White bulldozer, where the punch

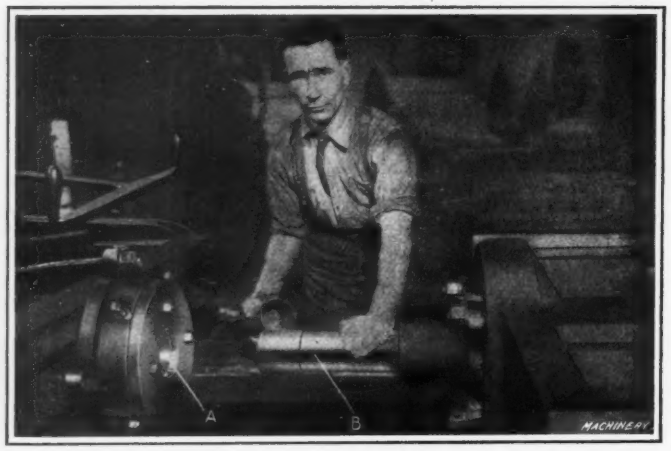


Fig. 5. Third Redrawing Operation on Williams & White Bulldozer

and die are held in the same manner as for the first redrawing operation. Annealing, washing, etc., follows the second redraw. The head end of the cartridge case is now indented in a Williams & White bulldozer, where the base end is formed to the shape shown at *D* in Fig. 3, and is then given the third redrawing operation without annealing as shown in Fig. 5. Here the operator removes the case from a tank which is filled with a lubricant—"Viscosity"—and places it on the punch, as illustrated, when the cross-head is on the backward stroke. The shape of the case after this operation is shown at *D* in Fig. 3.

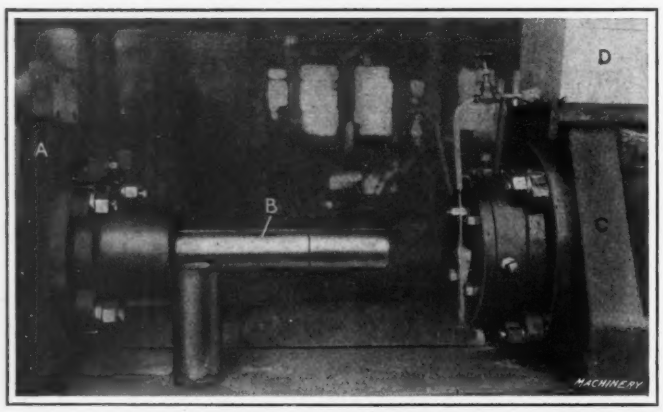


Fig. 6. Performing Fifth Redrawing Operation on a Frog and Switch Planer

Following the third redrawing operation, the case is again annealed, washed, etc., and is then taken to the Williams & White bulldozer, where the fourth redrawing operation is accomplished. The diameter and length of the finished case after this operation are given in the accompanying table. After the fourth redrawing operation, the case is annealed, and then taken to the second indenting operation. This is accomplished in a Williams & White bulldozer at the rate of 300 per hour.

At this point in the sequence, an operation is performed that is not general practice. This consists in drilling a ¼-inch hole through the primer pocket. In attempting to form the head of the cartridge case with the primer pocket solid, it was found that the metal in the proximity of the pocket was much harder than at the rim. This is just the reverse of what is

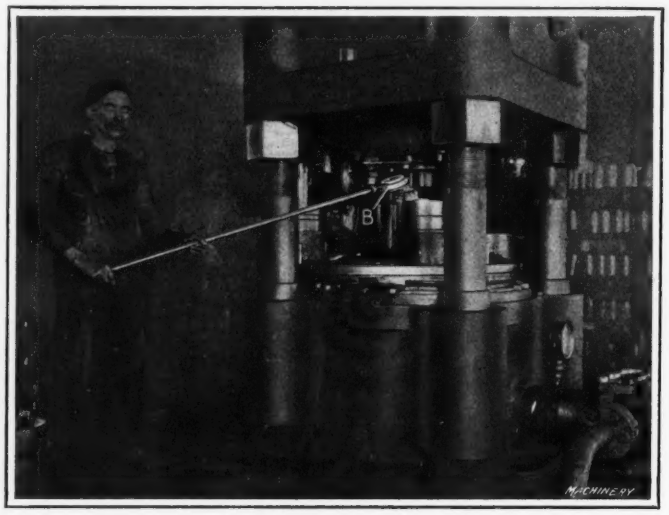


Fig. 7. Heading Cartridge Cases on a C. P. R. Heading Machine

required. In other words, the rim must be much harder than the center of the head. To overcome this difficulty, a hole was drilled through the pocket, and in heading, this allowed the metal to flow freely to the center, and thus prevented "packing" and subsequent hardening. Following the drilling of the hole in the primer pocket, the case is taken to a Toledo

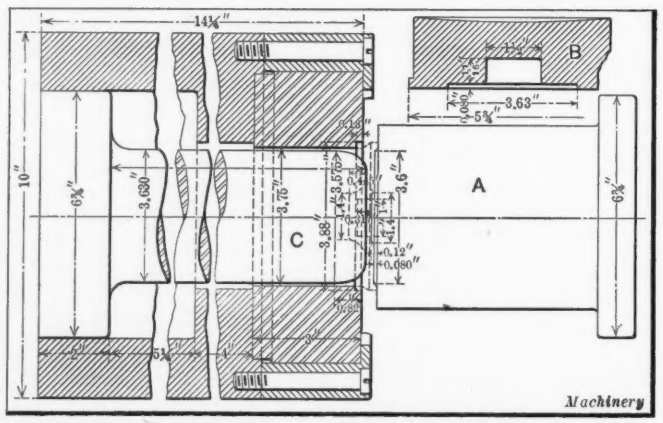


Fig. 8. Diagram showing Dies and Heading Tools used in Machine shown in Fig. 7

case trimmer, where the open end is trimmed, removing the ragged edge from the mouth of the case.

Fifth and Sixth Redrawing Operations

The fifth and sixth redrawing operations are handled on a frog and switch planer as shown in Fig. 6. In order to perform these operations on the planer, the entire cross-rail was removed and a large casting *A* serving as a punch-holder was fastened to the uprights. The redrawing punch *B* is therefore held stationary. The redrawing die, on the other hand, is held in a holder retained on casting *C* that is bolted to the planer table. The method of operating is to place the case on the punch when the planer table is on the return stroke.

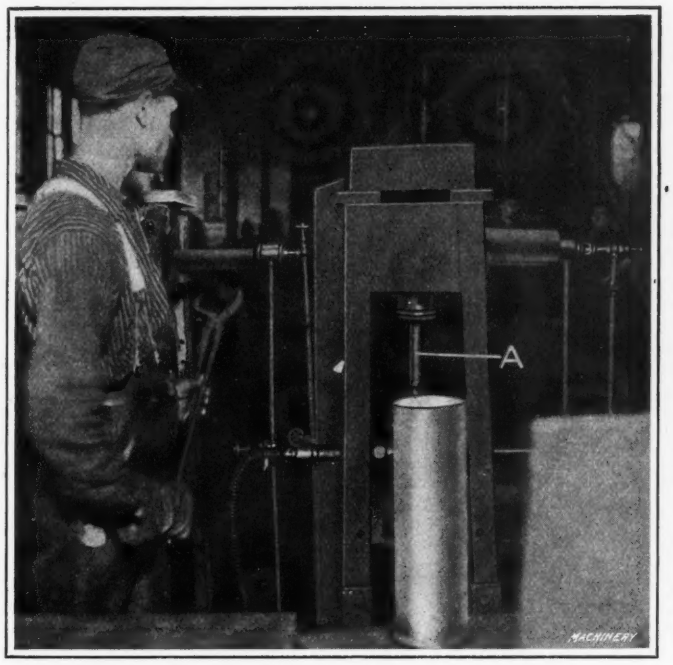


Fig. 9. Mouth-annealing Cartridge Case in an Improvised Annealing Furnace

Fig. 10. Testing Hardness of Cartridge Cases with the Scleroscope

The punch and die is lubricated by a lubricant held in box *D* which, of course, travels with the die. The case, in being forced through the die, slides down a trough into a box.

After the fifth redraw, the case is annealed, washed, etc., and is then given a sixth redraw which is accomplished in a similar manner to the fifth. The mouth of the shell is again trimmed on a Toledo case trimmer and from here is taken, without annealing, to the heading press.

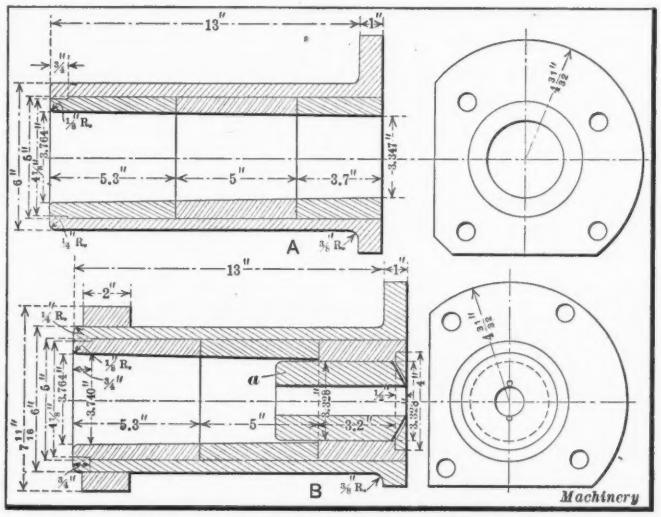


Fig. 11. Dies used for First and Second Tapering Operations on Cartridge Case

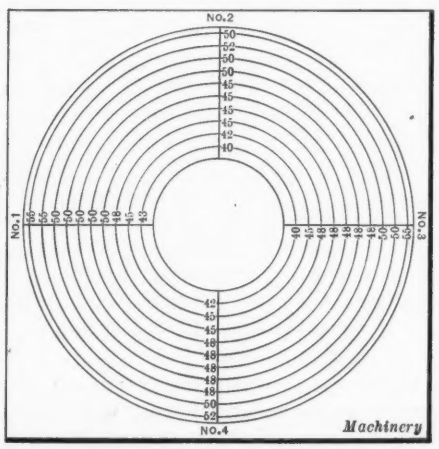


Fig. 12. Diagram showing Representative Scleroscope Reading taken on the Head of a Cartridge Case

Heading

The heading operation is now performed in the 350-ton press shown in Fig. 7, which is built by the Canadian Pacific Railway. This machine is provided with a table of the indexing type which carries four sets of dies, shown in detail in Fig. 8. In heading, the case is given two blows; the first is delivered by punch *A*, which fills in the primer pocket. Punch *B*, which is held on a rod as shown in Fig. 7, is then placed over the case and a flattening blow is delivered. While these operations are being performed the case is supported by punch *C*, Fig. 8.

Mouth-annealing and Tapering

The next operation is mouth-annealing. This is accomplished in a simple furnace shown in Fig. 9. It comprises a stand which supports an air drill, a spindle *A*, fitted into the driving socket of the drill, and a table attached to this as shown. The case is supported on this table and rotated by the air drill. The annealing is done with an oil burner. The case is allowed to rotate for thirty-five seconds and is heated to a temperature of 800 degrees F. for a distance of about 4½ to 5 inches from the mouth of the case.

After mouth-annealing, the cases are allowed to cool off in the air, and when cool are taken to a Williams & White bulldozer. Two tapering operations are necessary to bring the case to the correct shape and size. The dies used for this purpose are shown in Fig. 11. The first tapering die is shown at *A*, and, as will be seen, is made in three pieces. For the first tapering, the mouth of the shell is not supported, as the reduction is carried along the entire body. In the second tapering, however, the reduction at the mouth is greater and necessitates using a supporting bushing *a*, as shown at *B*.

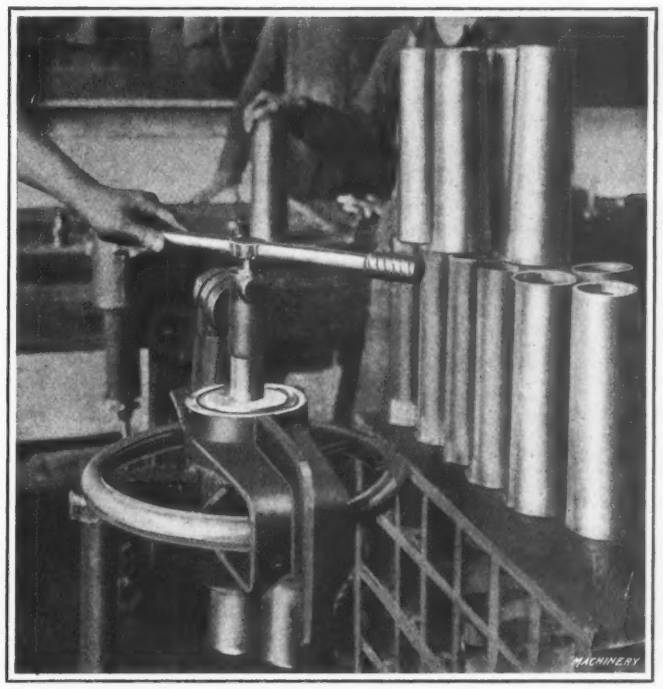


Fig. 13. Hand-reaming Primer Pocket in Head of Cartridge Case

Machining Head and Mouth Ends of Case

Following the tapering operations, the cartridge case is taken to the machining department where a series of operations is performed on the head and mouth ends. These operations are

performed on a Bullard facing, chamfering and trimming machine in the manner described in the December number. The order of operations is: first, rough-drill and counterbore; second, face, trim and chamfer head; third, finish-chamfer and face; fourth, under-cut primer seat; fifth, finish-counterbore; sixth, tap with collapsing tap; seventh, trim and chamfer mouth.

The case is now taken to a special reaming fixture shown in Fig. 13, where the primer pocket is finish-reamed. Hand tapping of the primer pocket follows this and is accomplished in a similar fixture. The case then passes through a series of inspection operations, consisting in gaging the diameter and thickness of the head, depth, diameter, etc., of the primer pocket; overall length, diameter of mouth, etc. Another inspection is to look through the case, from the head end, to detect whether any free spelter is present or not. The cartridge case is then stamped on the head end in a Noble & Westbrook stamping machine. This finishes the machining and inspection operations on the case.

Testing for Hardness

As has been previously mentioned the hardness of the metal is tested before and after each annealing and redrawing operation, and for this purpose the scleroscope is used. Fig. 10 shows an inspector taking a series of readings on the head of the cartridge case. About one per cent of the daily production is inspected in this manner, and Fig. 12 shows a representative reading. The body of the case is also tested for hardness at the points indicated in the illustration accompanying the table. This table also includes the scleroscope readings obtained before and after every annealing and redrawing operation. For taking a reading on the body of the case, it is placed on the horn *A* shown in Fig. 10. Final inspection, packing, etc., finishes the operations on the case.

* * *

SPEED OF BAND SAWS

In reply to an inquiry for the most suitable speeds for band saws, we are informed by the Berlin Machine Works, Beloit, Wis., that this firm advises the following speeds for both band saws and circular saws for the materials given below:

For cutting the softest materials, such as unseasoned pine, bass wood, etc., a maximum speed of 10,000 feet per minute is recommended.

For seasoned soft wood, and unseasoned comparatively hard wook—oak, gum, etc.—a speed of 9000 feet per minute is recommended.

For seasoned comparatively hard wood and unseasoned hard wood, such as maple, hickory, etc., a speed of 8000 feet per minute is recommended.

For seasoned hard wood and unseasoned exceedingly hard wood, a saw speed of 7000 feet per minute is recommended; such exceedingly hard wood would be frozen unseasoned maple, for example, which is cut extensively in the mills of northern Wisconsin and Michigan.

The Defiance Machine Works, Defiance, Ohio, recommend in the operation of the band saws built by them a speed of 5000 feet per minute.

The Curtis Saw & Sawmill Machinery Co., St. Louis, Mo., advises that for small band saws, that is, two-inch and smaller, a linear speed of about 4700 feet per minute is recommended. These saws are usually run over a wheel three feet in diameter, having a speed of 500 R. P. M.

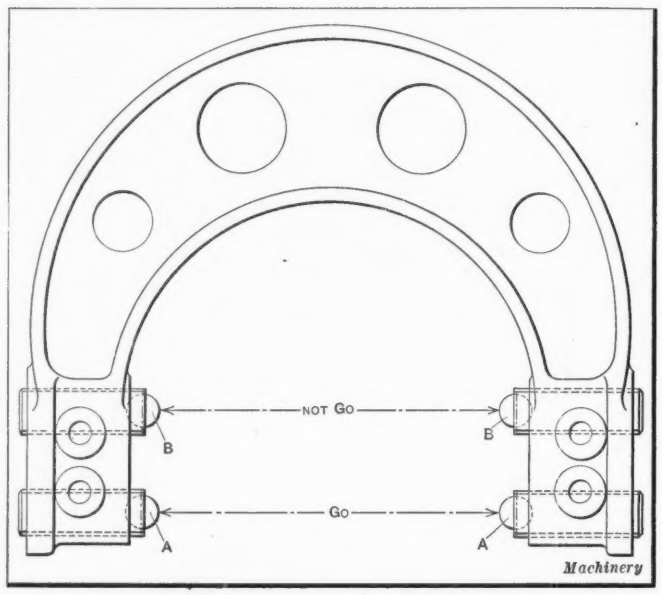
J. A. Fay & Eagan Co., Cincinnati, Ohio, states that when sawing wood the speed of band saws may be from 8500 to 10,000 feet per minute, depending upon the size and type of the saw.

* * *

One of the large automobile manufacturers publishes a bulletin for the benefit of his men. The bulletin is published mainly in the interest of safety, and is an excellent little publication; but from it we glean how completely dehumanized is the plant, for we are told that B 6073, D'8549 and A 416 offered suggestions last month. How much better Jones, Brown and Smith would have felt if their *names* had been mentioned instead of their *numbers!*

LIMIT GAGE WITH BALL CONTACT POINTS

A limit gage of British design made by Smith, Barker, Willson & Co., Halifax, England, is shown in the illustration, in which hardened steel balls are used for the contact points. The balls are seated in plugs to a depth slightly greater than a half diameter and are peened in place. The advantage of the ball contact points is cheapness of construction. The balls are hard and true, and when worn can be quickly and cheaply replaced. The plugs in which they are seated are adjustable, of course. Standard end measure gages are used to set them to the required "go" and "not-go" sizes.



British Limit Gage with Ball Contact Points

* * *

ASSEMBLING PLUG AND RING GAGES OF SAME DIMENSIONS

It is well known among toolmakers, inspectors and users of accurate gages that plug and ring gages of the same diameter may be assembled by an expert, and the plug will move freely within the ring so long as it is kept in motion. But the moment the plug is allowed to come to rest the ring will grip it tightly, and much force will be required to push the plug out. The question is, how is it possible to put a plug measuring say exactly one inch into a ring gage measuring exactly one inch with an oil film between the opposing surfaces? The theory advanced by one concern that has made accurate gages for many years is elasticity of the plug and ring. The ring is supposed to stretch and the plug to compress when assembled, sufficiently to provide the necessary space for the intervening oil film. The theory is apparently borne out by the fact that as long as the plug is kept moving in the ring the gages fit smoothly, but the moment movement is stopped the oil is squeezed out and they freeze together.

Another theory advanced to account for the phenomenon is that the surfaces of the plug and ring even though highly finished, are quite irregular when viewed under the microscope, and that the irregularities act much the same as fur on an animal when smoothed by the hand. Under pressure, these minute excrescences are pressed down, giving way before the pressure of the oil film, but as soon as motion between the opposing parts ceases these irregularities tend to return to their original positions, thus interlocking and causing seizure. When measuring a plug or ring, the measurement, of course, is from the tops of these molecular hills.

* * *

High-speed steel has worked many wonders and it is not surprising that some ridiculous specifications have been made by those unfamiliar with its real qualities. One enterprising railway official, thinking he could facilitate the movement of cars on sidings, requested high-speed steel pinch bars!

GEAR TEETH WITHOUT INTERFERENCE OR UNDERCUTTING

DESIGNING NON-INTERFERING GEAR TEETH AND GENERATING THEM WITHOUT UNDERCUT FLANKS

BY JOHN EDGAR*

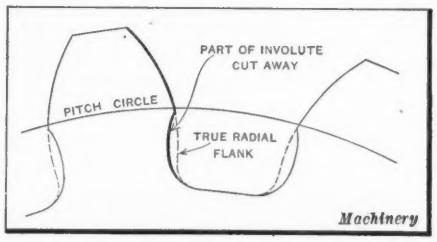


Fig. 1. Way in which Undercutting Action takes Place on a Twelve-tooth Pinion of 14½-degree Pressure Angle

UNDERCUTTING and interference of the teeth are to be avoided in all types of gearing, and to avoid one condition without having the other is a problem that must be given considerable attention. The tendency to produce undercut teeth is the one disadvantage of the processes of generating gear teeth from a tool shaped with straight sides similar to those of a rack, the undercutting being encountered in all cases where the pressure angle is less than 30 degrees and the addendum of the rack is the reciprocal of the pitch number. It appears in all gears of less than thirty-two teeth with the standard 14½-degree pressure angle. This undercutting is caused by the interference of the point of the tool in rolling out of the tooth, causing it to cut into the flank of the tooth and also to destroy a portion of the involute curve below the pitch line. The involute form at the point where the undercutting takes place is of proportionately greater value than at other points along the tooth face, as here the actual rolling action of the teeth on one another is attended with more sliding action than that which takes place above the pitch line, so that less wear will occur, greater pressure may be exerted, and the tooth will retain its shape better when this bearing surface is not lost by undercutting.

Undercutting is a serious matter in the standard 14½-degree involute system when gears of the smaller sizes and numbers of teeth are to be generated. To overcome trouble from this source, the use of the 20-degree pressure angle has been advocated; and as the undercutting action of the tool does not extend beyond the seventeen-tooth pinion, and is present in those gears with smaller numbers of teeth in a much less degree, the 20-degree pressure angle has much that can be said in its favor and is widely used in the case of generated gears. The stub-tooth which is now generally used in the case of the automobile transmission is usually of the 20-degree pressure angle type, which does away with undercutting almost entirely. But there are reasons why the 14½-degree tooth is to be preferred in many cases, and on that account the 14½-degree system will be considered in the present article, the examples being taken from gears of that pressure angle. It will be obvious that the treatment is universal in its application, and that the methods can be as easily applied to any system of involute teeth that may be under consideration. As previously mentioned, the undercutting action of the tool will occur in the case of gears of less than thirty-two teeth with the standard addendum. The actual undercutting increases as the number of teeth becomes smaller and is of a very undesirable nature in the case of a twelve-tooth pinion, as will be realized from an examination of Fig. 1, while pinions with less than twelve teeth will be so badly undercut as to be of little value in the transmission of uniform motion. In addition to affecting the wear of the teeth and their proper action, undercutting also weakens the teeth considerably.

A method of overcoming trouble from undercut teeth, which is now commonly used in automobile drives, is to make the pinion with long addendum teeth, thus avoiding the interference of the teeth and also the undercutting of the flanks. The long addendum is now almost exclusively used in the case of bevel gears; but there is no reason why it may not be employed in spur gears produced by the generating process, and even in the case of spur gears cut with a formed milling cutter. In the latter case, the involute can be made of the theoretical shape, because no correction will be necessary for the undercutting, as with the teeth of standard generated type; neither will the points of the teeth have to be thinned to avoid interference, as there will be no tendency for the teeth to interfere in properly designed gears. The modified radial form of the flanks of the teeth below the pitch line will allow of free milling, which is impossible with the pinions of standard generated tooth proportions.

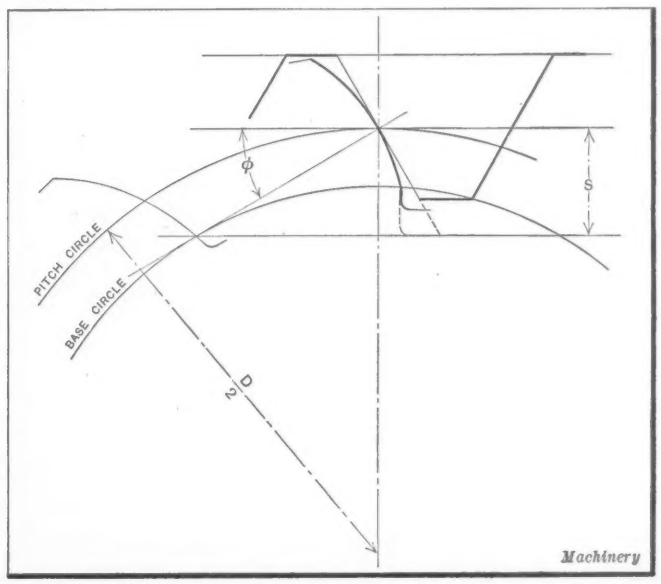


Fig. 3. Diagram illustrating Derivation of Formula for Maximum Addendum S

Compactness of design makes it necessary to use pinions with small numbers of teeth when large ratios are to be employed. In designing the gears with long addenda, the fact that must be kept in mind is that the wear of the tooth increases as the point of contact nears the tip of the tooth, so that the aim should be to keep the addendum down to the minimum in order that the contact shall be confined to the region of the pitch point. The pure rolling action of the teeth on each other takes place at the pitch point and is confined to a line at this point. This can be practically demonstrated by a pair of gears that have been run under load for a short time, in which the wear will show itself at the point of the tooth and at the region of the base line, while the area around the pitch line will show little evidence of wear. Of course, in a pair of gears that have had hard service, the wear all along the tooth will be marked so that the preceding observation may not seem to be quite correct; but if the gears have been in use for only a short time, the evidence will bear out this assertion.

Were it not for the sliding action of the teeth, gears would last indefinitely, as the rolling of the teeth on one another would compress the metal and eventually produce a hard glazed surface. The wear due to this sliding action is more in evidence in the case of small pinions than in gears of com-

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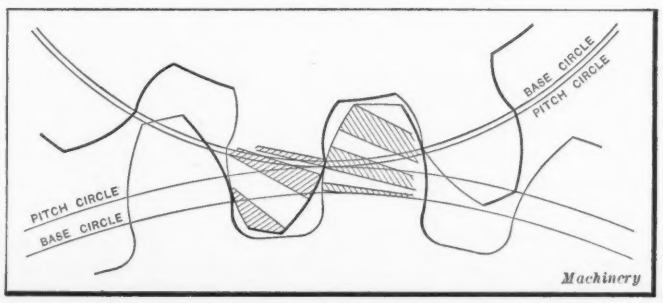


Fig. 2. Relative Sliding Action of Gear Teeth on each other

paratively large size; and the teeth of the pinion being proportionately longer than those of the gear have a greater percentage of this sliding action. Therefore, the addendum of the pinion must only be lengthened by an amount which is sufficient to do away with interference of the teeth, and to give a proportion that can be generated with little or no undercutting. Fig. 2 illustrates the extent of the sliding action. It will be seen that the tooth curves are divided into proportional spaces, the dividing lines being drawn tangent to the base lines, and they will coincide with the pressure line when the teeth come into contact at these points. The difference in the length of the space on one tooth and the corresponding space on the mating tooth is the amount of sliding action that occurs while the gear is rolling through an angle equal to that between the lines; and the sliding action is distributed over a wider area in the teeth of the gear.

To avoid undercutting in the teeth of any pinion generated with a straight rack-shaped tool, the depth of the cut below the pitch line must not exceed an amount given by the formula:

$$S = \sin^2 \phi \times \frac{D}{2} \qquad (1)$$

S = maximum addendum for the rack tooth;
ϕ = angle of the tooth;
D = pitch diameter, as shown in Fig. 3.

From the preceding formula we find that to avoid undercutting in the twelve-tooth pinion the tool should not cut deeper than 0.375 inch when the diametral pitch is 1; and a tool that extended only this distance below the pitch line would not cut into the radial flank shown dotted in Fig. 1. Also a rack with teeth projecting no further than 0.375 inch beyond the pitch line would roll perfectly with the type of tooth shown in Fig. 1 when made with the theoretical radial flank. Any extension of the teeth of the rack beyond this limit will cause interference between the teeth of the rack and the flanks of the teeth in the gear. However, the interference between the teeth in a gear of, say, twenty-four teeth when in mesh with a pinion with radial flanks as shown in Fig. 1, will not be so bad as between the rack and pinion; and the limiting addendum is not so short, being 0.45 inch in this case. This limiting addendum for any combination of gears is easily found, and an interference diagram may be drawn for a pair of gears as shown in Fig. 4. This limit is not so easily determined as in the case of a rack, but the values may be tabulated and a chart constructed that can be used with greater facility than is possible in solving the formula for each combination.

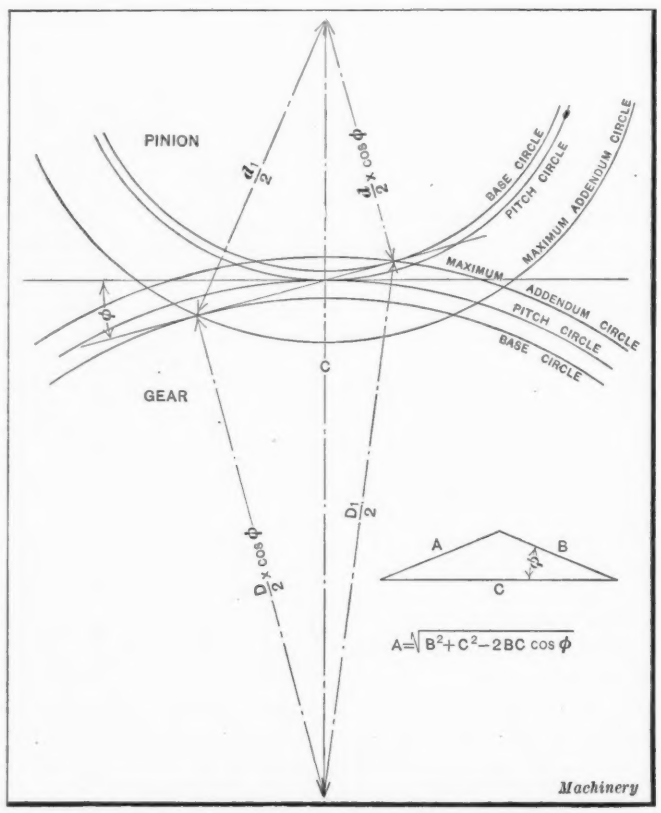


Fig. 4. Interference Diagram for a Pair of Spur Gears

The limiting factor in the case of the gears is the same as that with the rack, being the point of intersection of the addendum circle, the pressure line, and the base circle of the mating gear, the problem in each case being to find the length of the radial line $\frac{D_1}{2}$. An examination will show that this resolves itself into the problem of finding the side A of the obtuse triangle, the formula for which is:

$$A = \sqrt{B^2 + C^2 - 2BC \cos \phi}$$

The center distance C is given by the following formula:

$$C = \frac{D + d}{2}$$

where D = pitch diameter of gear;
d = pitch diameter of pinion.

$$\frac{D}{2} = \frac{R}{1+R} \times C$$

where R = ratio of number of teeth in gear to number of teeth in pinion.

$$\frac{d}{2} = \frac{1}{1+R} \times C$$

Using these values in the trigonometrical formula we get:

$$D_1 = 2\left[C^2 + \left(\frac{C}{1+R}\cos\phi\right)^2 - 2\frac{C^2}{1+R}\cos^2\phi\right]^{\frac{1}{2}} \qquad (2)$$

$\frac{D_1 - D}{2}$ is the addendum and the diametral pitch P is the reciprocal of this expression:

$$P = 2 \div 2\left[C^2 + \left(\frac{C}{1+R}\cos\phi\right)^2 - 2\frac{C^2}{1+R}\cos^2\phi\right]^{\frac{1}{2}} - D \qquad (3)$$

Substituting values for cos ϕ we get for the 14½-degree system:

$$P = 2 \div 2\left[C^2 + \left(\frac{C}{1+R}.968\right)^2 - \left(1.878\frac{C^2}{1+R}\right)\right]^{\frac{1}{2}} - D$$

For the 20-degree system, the result is:

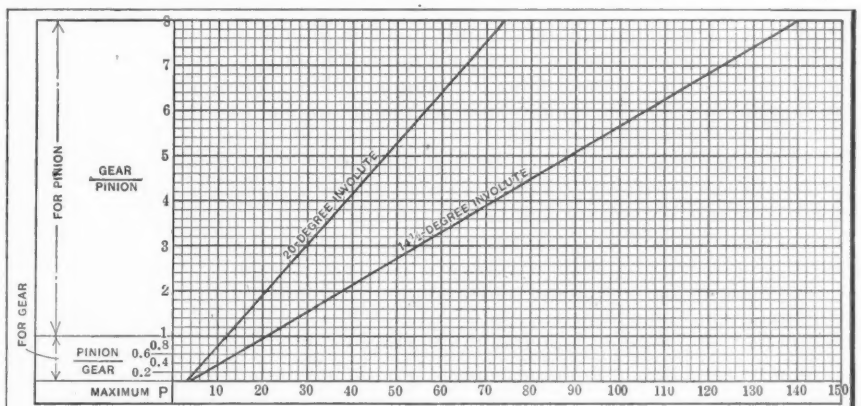
$$P = 2 \div 2\left[C^2 + \left(\frac{C}{1+R}.939\right)^2 - \left(1.766\frac{C^2}{1+R}\right)\right]^{\frac{1}{2}} - D$$

The values from the formulas have been calculated for 1-inch centers and the curves in Fig. 5 have been drawn, from which the limiting diametral pitch for any center distance and ratio up to 8 to 1 can be obtained. Since the pitch found in this way is based on the standard proportions of a tooth, the maximum value for any greater pitch is equal to the reciprocal of the pitch found by the use of the chart. Thus, if the maximum pitch found from the chart is 12, and the diametral pitch it is desired to use is 8, then the maximum addendum for the gear with the teeth cut to 8 pitch is the same as that for a standard 12-pitch gear or 1/12 inch long. The chart can also be used to obtain the minimum center distance for a pair of gears of a given ratio and pitch.

As an example to explain the use of the chart, suppose that a pair of gears of 5 to 1 ratio are to be run on 10-inch centers and we wish to have them mesh without interference; what diametral pitch can they be made? Find the ratio at the left of the chart and follow along until the line intersects the 14½-degree curve, then read down to the maximum pitch for a 1-inch center distance. The result is 90; divide this by the given center distance of 10 inches, which gives 9 as the required diametral pitch. As another example assume that a ratio of 4 to 1 is to be satisfied with gears of 5-pitch; what is the center distance that will give gears which will run without interference? Entering the chart from the left at the proper ratio line, as before, we find the maximum diametral pitch for a center distance of 1 inch to be 73. Dividing this by the pitch we get 73 ÷ 5 = 14.6 inches as the required center distance. Again assume that it is desired to

have gears with 12 and 48 teeth of 5-pitch mesh without interference; what will be the proper addendum for the pinion? The ratio is 4 to 1, and the maximum diametral pitch from the chart is 73 for 1-inch centers. The center distance is $\frac{12+48}{2\times 5}=6$ inches, and the maximum pitch for 6-inch centers is $73\div 6=12.167$. The maximum addendum is then 1/12 or 0.0888 inch. On the other hand, suppose we have to satisfy a ratio of 5 to 1 and desire to use gears of 10-pitch with standard addendum; what is the shortest center distance that can be used? From the chart, the maximum diametral pitch, corresponding to the ratio of 5 to 1, is 90; this is the pitch at a 1-inch center distance, so that the minimum center distance for 10 pitch is $90\div 10=9$ inches.

The undercutting of the teeth in generating may also be avoided by using a tool of greater angle than that of the teeth that are being shaped, still making the teeth of the standard proportions. It is a well known fact that but one involute curve can be generated from a base circle of given diameter; and as the tool represents a tangent to the curve, corresponding to the position of the tool, a tool of any angle, within the limits of the portion of the curve of which the tooth is made up, can be used to generate the tooth by rolling the tool at the proper distance from the base circle. While the involute portion of the tooth curve will be the same, the flank, *i. e.*, that portion of the tooth below the base line of the gear, will be fuller as the angle of the tool is made greater. At this point it may be well to mention that it is impossible to generate a radial flank on the teeth of gears with a straight sided tool, the actual flank that is produced being either undercut or too full.



NOTE:—When the ratio of the gearing is an integral number, the maximum value of the pitch P at which interference begins applies only to the pinion; when the value of the ratio is a decimal, the maximum value of the pitch applies to the gear. Usually the pinion is the determining factor. The chart gives the maximum diametral pitch P which can be used without interference, for a given ratio of gearing and a center distance of 1 inch. To obtain the maximum diametral pitch for any required center distance, divide the value of the pitch obtained from the chart by that center distance. Similarly, to determine the maximum addendum for any required center distance and pitch, divide the given center distance by the maximum pitch obtained from the chart for a center distance of 1 inch. To get the center distance for any required ratio and pitch, divide the maximum pitch obtained from the chart for a center distance of 1 inch by the diametral pitch.

Machinery

Fig. 5. Chart showing Maximum Values of Pitch and Addendum without Interference of Teeth

It will be found that the maximum addendum, according to Fig. 5, is the limiting depth that can be used in generating gears with a straight sided tool, and still produce gears with teeth which will not interfere, and which will not have undercut teeth. However, it is possible to generate teeth that have a minimum amount of undercutting by a compromise between the angle and depth of cut. This method is described in the following. From Fig. 6, we see that the minimum angle of a cutting tool to generate a gear tooth without undercutting is proportional to the ratio of the depth of cut to the radius of the base circle, the ratio being the versine of the angle ϕ. Thus:

$$\frac{\text{Depth below base line}}{\text{Radius of the base line}}=\text{versine }\phi^g. \qquad (6)$$

In the case of a twelve-tooth pinion of 14½-degree pressure angle and 1-pitch, we get:

$D=6$ inches;

Radius of base circle $=6\times\cos 14\frac{1}{2}$ degrees $=5.808$ inches;

Root radius $=6-1=5$ inches;

Depth below base line $=5.808-5=0.808$ inch;

Versine $\phi=0.808\div 5.808=0.1375$;

$0.1375=$ versin 30 degrees 24 minutes.

The radius of the base circle is the pitch radius multiplied by cos ϕ. The roll radius is the base circle radius divided by cos ϕ^g. To distinguish between the pressure angle of the gear and the angle of the tool with which it is to be generated, call the pressure angle of the gear ϕ, and the angle of the tool ϕ^g. The radius at which a tool of 30 degrees 24 minutes angle must be rolled to produce the involute curve for the required pinion is $5.808\div 0.863=6.73$ inches. The tooth shape is shown in Fig. 7. We will find, however, that a gear with twelve teeth cut in this manner will not mesh with any other gear without interference. This fact will be understood by referring to Fig. 7. By an application of the chart shown in Fig. 5, we will find that in the case of teeth with standard addenda, for an even ratio of 1 to 1, gears with less than twenty-three teeth will not mesh without interference; and for a ratio of 2 to 1, the minimum number of teeth will be twenty-seven and fifty-four. At these ratios with less teeth in the gears, the teeth must either be undercut or the addenda made shorter. We will also find by applying Formula (1), that the teeth of the twenty-three and twenty-seven tooth gears will be undercut when generated with a straight sided tool of the same angle as the pressure line. This undercutting can be avoided by using a tool of 16 degrees 58 minutes angle, as found by Formula (6).

It may not be convenient to use gears with as many teeth as the minimum for non-interference requires, according to the method of the preceding paragraph; and yet the undercutting of the twelve-tooth pinion may be undesirable. The extremely long addendum that would be necessary to avoid the undercutting action when a tool of standard angle is used may be considerably reduced by making it just the length required to avoid interference between the teeth of the pair of gears, as found from the chart for the desired ratio. Consider the 2 to 1 ratio with pinion of twelve teeth. The chart gives the maximum addendum as 0.45 inch for 1 pitch; by Formula (1) that of the rack-tooth or tool is 0.375 inch. If the tool is made to cut 0.45 inch below the pitch line and no undercutting is desired, the required angle of the tool is found from Formula (6) to be 16 degrees 51 minutes. If the depth of the space is to remain the same as for the standard tooth and equal to $2\div P$, the depth of the space in the gear below the pitch line will be $2-0.45=1.55$ inch. We find by means of the chart that this is excessive, as the maximum addendum for a gear of twenty-four teeth and a ratio of 2 to 1, at 18-inch center distance, will be but 1.313 inch. The excess in depth is $1.55-1.313=0.237$ inch, and if the tool is made to cut to this depth undercutting of the teeth will result. (See Fig. 1 for typical case.)

The use of the standard tool is out of the question in this case, as the amount of undercutting would be excessive even when compared to the standard twelve-tooth pinion shown in Fig. 1. Even if the tool is made to an angle ϕ^g that would avoid undercutting at the depth of the maximum addendum, *i. e.*, 1.313 inch, for the twenty-four-tooth gear, the extra depth of cut would still cause a slight undercutting to take place. A practical method of compromise in this case would be to divide the amount of undercutting between the two gears so that the tool would be set to a depth below that required for the generating of non-interfering teeth, and divide the excess proportionally, *i. e.*, make the tool for the pinion at the angle required by Formula (6) and $0.45+\frac{0.237}{3}=0.529$ inch below

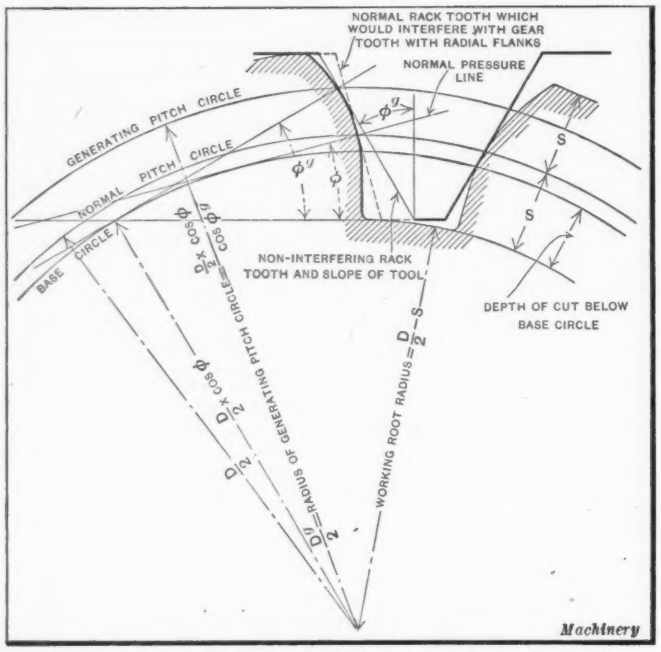

NORMAL RACK TOOTH WHICH WOULD INTERFERE WITH GEAR TOOTH WITH RADIAL FLANKS
NORMAL PRESSURE LINE
GENERATING PITCH CIRCLE
NORMAL PITCH CIRCLE
BASE CIRCLE
NON-INTERFERING RACK TOOTH AND SLOPE OF TOOL
DEPTH OF CUT BELOW BASE CIRCLE
RADIUS OF GENERATING PITCH CIRCLE = D/2 x cos φ
WORKING ROOT RADIUS = D/2 − S
S
Machinery

Fig. 6. Diagram illustrating Derivation of Formula for Angle of Generating Tool

the pitch line; that for the gear, $1.313 + \frac{2 \times 0.237}{3} = 1.471$ inch below the pitch line and at the required angle for a depth 1.313 inch, as found from Formula (6). The better way would be to make the total depth of the tooth equal to the sum of the maximum addenda for the gear and pinion, respectively, for reasons to be disclosed later. It would not do to make the tool for the gear to the angle corresponding to a depth of 1.55 inch, as the flank would then be too full and the teeth would interfere. The maximum addendum found by the chart is the limit at which the tool angle ϕ^g can be taken and still avoid interference. When we are considering the case of gears with standard addenda teeth, the preceding compromise can be applied and gear teeth obtained with a minimum amount of undercutting.

The foregoing methods are most easily applied in the case of the planer tool which is almost universally used in generating bevel gears; the only thing necessary is to grind the tool to the angle ϕ^g and measure the teeth in the usual manner. It is also applicable to the case of the hob, and where a quantity of gears of a single number of teeth are to be produced the use of a special hob with the angle made according to Formula (6) is to be recommended in place of the more universal method of avoiding undercutting by doctoring the tooth shape of the hob by applying a curved correction. The latter method is a compromise at best, and must be accompanied by a similar correction to thin the points of the gear teeth, resulting in a shortening of the arc of contact. In making the hob, the lead of the thread must be equal to the pitch of the teeth of the gear at the rolling radius corresponding to the angle ϕ^g and is given by the following formula:

$$\text{Lead of hob thread} = \frac{\cos \phi}{\cos \phi^g} \times P' \qquad (7)$$

where P' is the circular pitch of the standard gear.

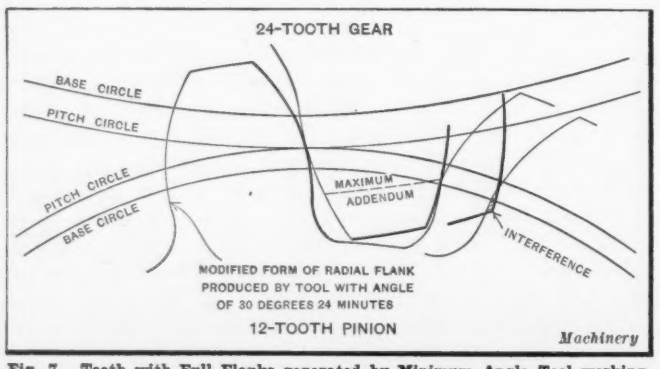


Fig. 7. Teeth with Full Flanks generated by Minimum Angle Tool working on Twelve-tooth Pinion and Twenty-four-tooth Gear

The thickness of the tooth of the hob must be such that the thickness of the tooth of the gear at the normal pitch line is equal to $\frac{P'}{2}$. This result can be obtained by making the hob tooth space equal to the thickness of the tooth of the gear at the rolling pitch line; and the thickness of the tooth at that point in the gear can be obtained by the method given in my article entitled "Plotting the Involute Curve," which was published in the February number of MACHINERY. The thickness of the hob teeth is taken at a depth equal to the depth of the space in the gear below the pitch line.

The tooth and space of the long addendum gears are, as a rule, not made of equal thickness. It is usual to make the teeth of such a thickness at the pitch line that they will be approximately of equal thickness at the mean depth. This would be the result if a standard hob were used to generate the teeth, as the thickness of the long addendum tooth would be that at the line $a - a$, the thickness of the short addendum mating tooth that at the line $c - c$, and the average thickness that at the line $b - b$, *i. e.*, the normal pitch line of the rack or hob. The pitch of the teeth in the rack or hob does not alter, no matter what location is taken for the pitch line, as with the gear teeth which increase or decrease in pitch with any shifting of the pitch line. To find the thickness of the teeth for the different addenda, we may solve the problem by proportion. If the sides of the rack teeth are

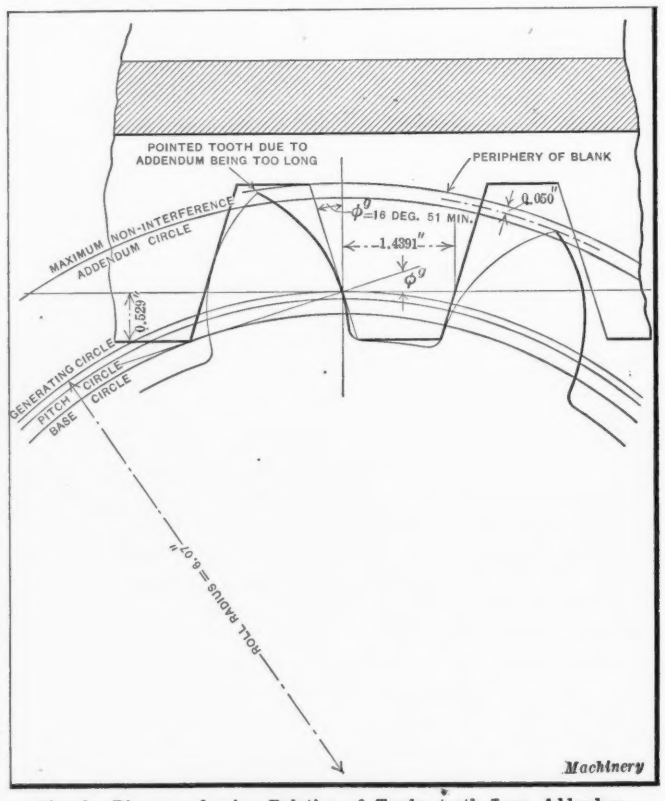


Fig. 8. Diagram showing Relation of Twelve-tooth Long Addendum Pinion and Hob

produced until they intersect each other, the space S'' from the normal position of the pitch line to the intersection of the sides, midway in the depth of the tooth, may be found by the formula:

$$S'' = \frac{0.7854}{P \tan \phi} \qquad (8)$$

where S'' has the value shown in Fig. 8;

P = diametral pitch;

ϕ = pressure angle of gear.

The thickness of the space at any location of the pitch line other than the middle position may be calculated from the formula:

$$T^n = \frac{S'' \pm a}{S''} \times T \qquad (9)$$

where T^n = thickness of rack tooth at any distance from normal pitch line;

a = distance pitch line is shifted from middle position;

T = normal thickness of teeth at line $b - b$.

The plus sign is used when the shift is outward from the normal position $b - b$, and the minus sign when the shift is inward toward the apex of the angle made by the sides of the teeth. The shift a is the same in both gears of a pair, the signs being opposite. As an example of what procedure to follow in finding the thickness of the hob tooth for a hob made with the teeth formed to the angle found by Formula (6) instead of the standard pressure angle, we will take the case of the long addendum twelve-tooth pinion previously referred to; the ratio is 2 to 1, the gears have twelve and twenty-four teeth, the addendum is $0.45 + \frac{0.237}{3} = 0.529$ inch, and angle of the tooth 16 degrees 51 minutes.

Normal pitch radius = 6 inches;
Root radius = $6 - 0.529 = 5.471$ inches;
Base line radius = 5.808 inches;
Roll radius = $5.808 \div 0.957 = 6.07$ inches.
The thickness of tooth on the pitch line is:

$S'' = 3.137$ inches;
$a = 1 - 0.529 = +0.471$ inch;

$$T^n = \frac{3.137 + 0.471}{3.137} \times 1.5708 = 1.806 \text{ inch.}$$

The thickness of the tooth of the gear at the roll radius is found by the following method, as described in the article "Plotting the Involute Curve:"

One-half the angle of the tooth at the pitch line = $\frac{1.806}{2 \times 6} = 0.150$ radian;
b at ϕ is 0.00555 radian;
b' is $0.150 + 0.0055 = 0.155$ radian;
b' is one-half the tooth angle at the base line of the gear, and is expressed in radians:
b at $\phi^g = 16$ degrees 51 minutes is tan $\phi - \phi$ (in radians);
ϕ in radians is $\phi \div 57.296 = 16.85 \div 57.296 = 0.294$ radian;
$\tan \phi = 0.30287$;
$b = 0.30287 - 0.294 = 0.00887$ radian;
½ angle of tooth at a radius of 6.07 inches is $0.1555 - 0.00887 = 0.14663$ radian;
Thickness of tooth at a radius of 6.07 inches is $2 \times 0.14663 \times 6.07 = 1.739$ inch;
The lead of the hob is $\frac{2 \times 6.07 \times 3.1416}{12} = 3.1783$ inches;
The thickness of the hob tooth at the depth of the roll radius or at $6.07 - 5.471 = 0.599$ inch from the end of the teeth, is then $3.1783 - 1.7392 = 1.4391$ inch. The hob and gear are shown in Fig. 8.

It will be noticed that the ends of the pinion teeth are pointed and shorter than the teeth of the hob, and consequently have a shorter addendum than was intended. This is a point that will have to be looked out for in the design of long addendum gears, especially in the case of pinions with few teeth, as the involute curve of the opposite sides of the teeth will overlap, which results in pointing the teeth and shortening the addendum. The limiting addendum obtained from the chart for non-interference will lie inside the point of the tooth, and had that been the limiting length for the addendum the teeth would not have been pointed. It is well when using extreme addenda on the teeth of small pinions to check up the tooth for thickness at the point in the same manner as has been done to find the thickness at the roll radius, and if the term b is equal to the term b' the tooth will be pointed; if b is greater than b' the tooth will be shortened. No attention has been paid throughout this article to the extra depth of tool required for cutting the clearance. This can be added to the proportions of the tool, and if the corner of the tool is made to a radius equal to the amount of the clearance, the extra depth will have no serious effect on the tendency toward undercutting; it can be disregarded in the calculations, if the tool is to be left sharp. It will rest with the designer to decide whether he wishes to go to such a refinement. Gears made with tools at the angle ϕ^g will not be interchangeable with the whole involute series and will not mesh without interference with gears of smaller numbers of teeth. Their application is therefore necessarily confined to the generation of gears for special trains and especially where quiet running gears are necessary.

* * *

PLANISH-BROACHING

A square-hole transmission gear of the kind illustrated in Fig. 1 is almost sure to close in when hardened. More than that, it is almost sure to close in unequally on account of the varying thickness of metal surrounding the hole at different points. For instance, this particular gear, in hardening, will close in but slightly at the thin end, but will close in considerably at the thick section, owing to the contraction of the heavier mass of metal at this end. The result is that the gear will not slide freely without being ground out to fit the shaft after hardening. This, of course, is a slow operation and not a very satisfactory one, so the American La France Fire Engine Co. of Elmira, N. Y., through whose courtesy this job is shown, decided to try planish-broaching as a remedy. To this end, a planish broach was made approximately as shown on the Lapointe Machine Tool Co.'s broaching machine in Fig. 2. While there were no teeth on this broach, it was slightly relieved at certain points in order that the pull would not be excessive. All sections of the hole are reached by the broach, but not at the same time. The first section of the broach must enter the shrunken hole easily; the next section expands the hole in one direction; the third expands the hole in the other direction; and the last gives a final shaping to all four sides of the hole.

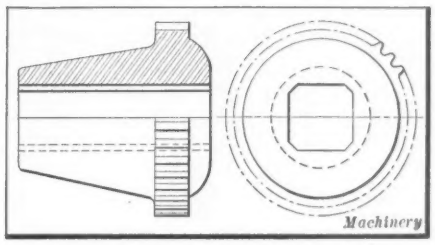


Fig. 1. Gear to be planish-broached

It is necessary to expand the gears about 0.004 inch at the thick section in order to straighten the hole, but to maintain this expansion permanently the broach must be made so that it will compress the stock about 0.008 inch. This makes allowance for the springing back of the metal after being expanded. This operation is performed exactly the same as any other broaching operation, using a lubricant to prevent the broach from tearing the sides of the hole. C. L. L.

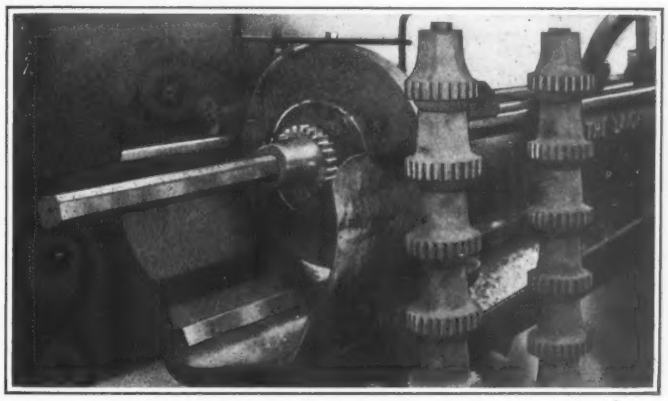


Fig. 2. Planish-broaching Operation

* * *

The manufacture of metal bodies for automobiles requires heavy presses of large capacity, especially if the largest parts are formed from one sheet. But in the majority of plants, the larger parts are made of two or more formed parts joined by autogenous welding that are afterward hammered smoothly into shape. The rough joint is ground off outside and is then hammered with the Pettengell post hammer to take out the wrinkles and roughness and to round off the curves to the desired radii.

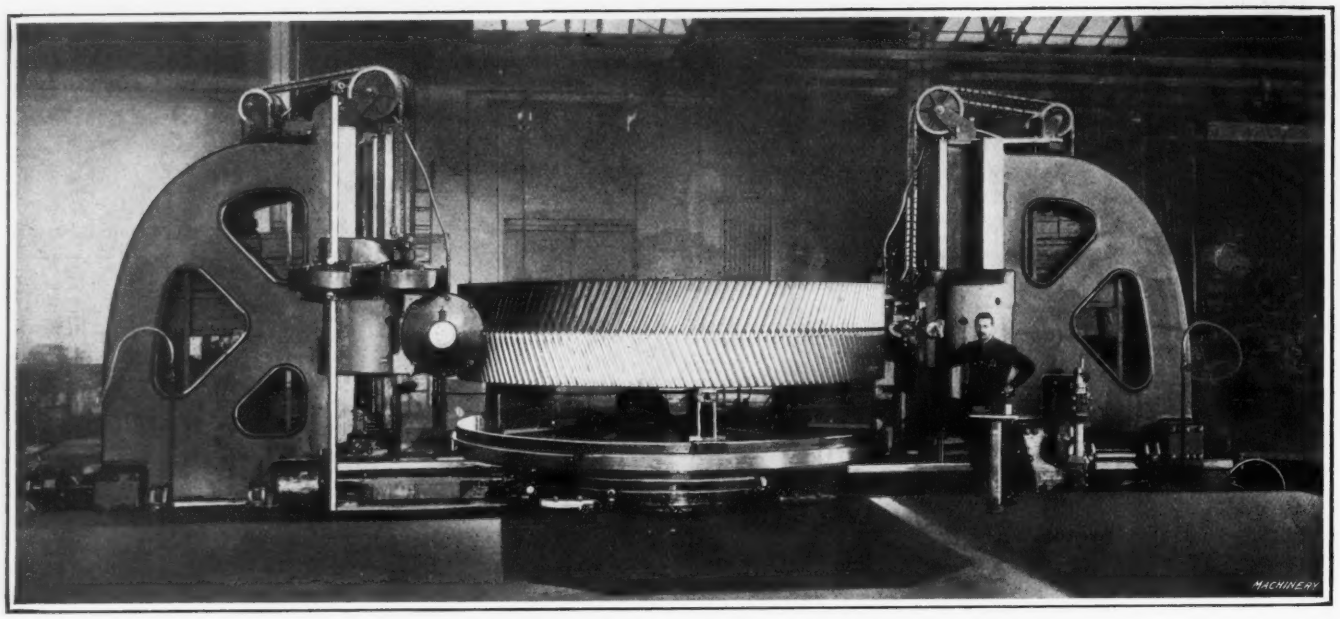


Fig. 1. General View of Falk Herringbone Gear Hobbing Machine working on a Large Gear

THE LARGEST HERRINGBONE GEAR HOBBING MACHINE*

A SPECIAL MACHINE DESIGNED AND BUILT BY THE FALK CO. FOR GENERATING WUEST TYPE OF HERRINGBONE GEARS

THE purpose of the following article is to describe what is believed to be the largest herringbone gear hobbing machine in the world; this is a special machine designed and built by the Falk Co., Milwaukee, Wis., for its own use in generating large herringbone gears. The capacity is for gears from 3 feet 2 inches up to 16 feet 3 inches in diameter, and up to 6 feet face width; teeth of all pitches up to ¾ diametral pitch can be cut. The floor space occupied by the machine is 43 feet long by approximately the same width, the height 16 feet, and the weight 150 tons.

Gears generated by this machine are almost invariably cut from steel castings, and the expense involved in building a machine for service of this kind is such that only a firm engaged in the manufacture of gears would have enough work for the machine to be able to earn a reasonable return on the investment. Hence, the term "special" gear hobbing machine is employed. At the present time a herringbone pinion generating machine is in course of construction, which has a capacity for cutting pinions from 13 inches up to 9 feet in diameter, and in face widths up to 6 feet. This machine will cut the teeth of pinions which are integral with shafts up to 22 inches in diameter.

It will be evident from the illustrations of the machine shown in Figs. 1 and 3 that it is equipped with two hobs carried by heads located at opposite sides of the table on which the work is mounted. One of these hobs starts cutting at the top of the gear blank and the other at the bottom, the desired angle for the herringbone gear teeth being obtained by employing a differential speed mechanism to transmit motion for rotating the work-table, and for feeding the cutter-heads on which the hobs are carried.

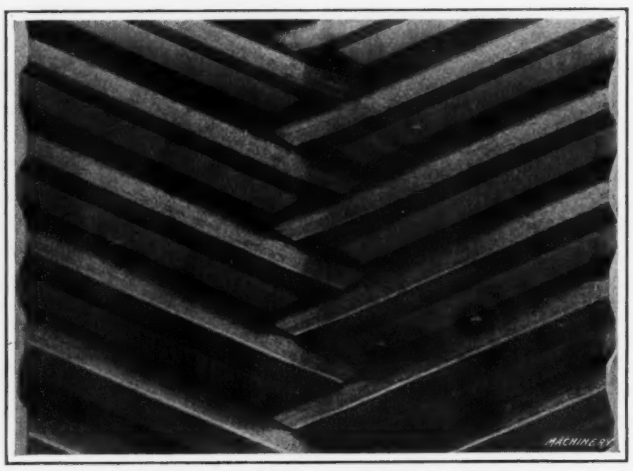


Fig. 2. Close View of Section of a Wuest Herringbone Gear

General Features of the Machine

The work-table on which the gear blank is mounted occupies a fixed position at the center, and the housings which support the cutter-heads at each side of the machine are mounted on ways which provide for sliding them back and forth to bring the cutter-heads into the proper positions for hobbing gears of various diameters within the range of the machine. Adjustment of the housings is obtained by means of very accurate lead-screws which were made for this purpose by the Boye & Emmes Machine Tool Co., Cincinnati, Ohio; these screws were furnished under a guarantee that the error in the lead of the thread should not exceed 0.001 inch per foot of length. Traversing of the housings is done by means of a 7½-horsepower auxiliary motor provided for this purpose, and the fine settings are made by hand. The housings are brought to approximately the required position by means of graduations on the bed, and dials are provided on the lead-screws to facilitate making the final accurate settings.

The cutter-heads are mounted on vertical bearings on the face of the housings, and the vertical feed is obtained by lead-screws made by the same manufacturer and having the same degree of accuracy as those employed for traversing the housings on the bed. It will be seen that the cutter-heads are counterweighted by means of weights located inside the housings; in the case of the hob which starts cutting at the top of the gear blank, the counterweight slightly exceeds the weight of the cutter-head, while in the case of the hob which works from the bottom of the gear blank, the counterweight is slightly less than the weight of the cutter-head. The reason

* In the February, 1915, number of MACHINERY a description was published of a herringbone gear hobbing machine built by the Fawcus Machine Co., Pittsburg, Pa. This machine has a capacity for hobbing gears up to 15 feet in diameter, making it a close competitor for the honor of being the largest herringbone gear hobber in the world.

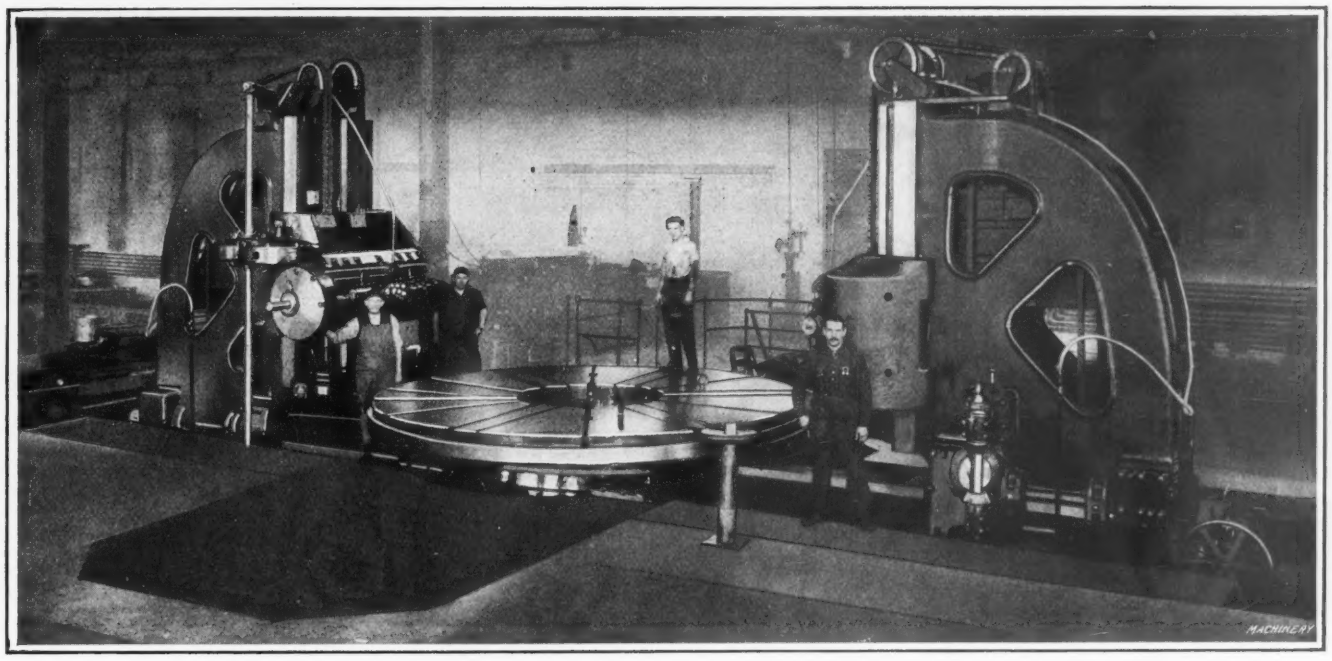


Fig. 3. Machine with Work removed from Table—Attention is called to Pit at Far Side of Machine in which All Driving Mechanism is located

for this is that it is desired to take up any lost motion between the lead-screw and nut in the same direction for both the cutter-heads, and also to have both of the lead-screws in a condition of tension. The arrangement of the feed mechanism will be described in a subsequent paragraph. The guides for the cutter-heads on the housings are of the narrow type, and the same is true of all guide bearings on the machine.

Arrangement of the Driving Mechanism

The main driving motor and the mechanism for making speed and feed changes are located in a pit on the opposite side of the machine from which the photographs reproduced in Figs. 1 and 3 were taken. The railing surrounding this pit can be seen in Fig. 3. The machine is driven by a 30-horsepower motor which transmits power to the arbors in the cutter-heads through a change-gear box that provides ratios of 1 to 2 or 1 to 4; after leaving the gear box the motion is transmitted through a train of bevel, spiral and worm gears to the cutter-arbors. A vertical shaft which carries the power up to one of the cutter-heads can be seen at the left-hand side of the machine in Fig. 1; and there is a similar shaft at the opposite side of the machine, which transmits power to the other cutter-head. In working out the design, care was taken to have the drive symmetrically arranged in order that torsional strains in the shafting would be equal for both of the cutter-heads. Further provision for accurate driving was made by employing the hunting tooth principle in the gears which transmit the motion to the cutter-heads; it may be mentioned that hunting tooth gears are also used at all points on the machine where the occurrence of wear would affect the accuracy of the results obtained.

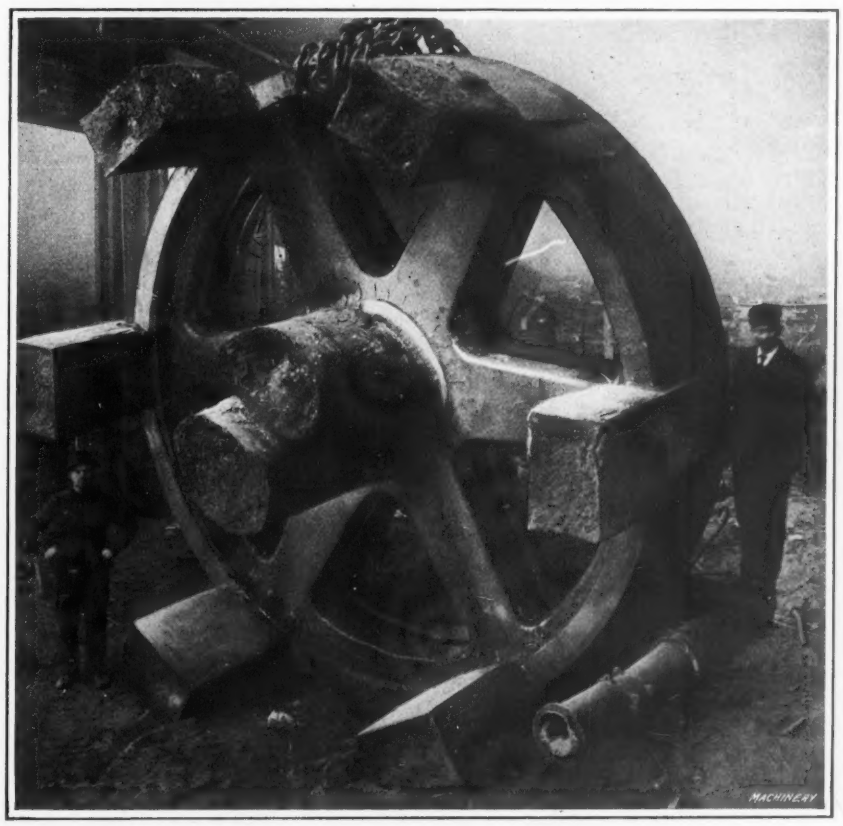


Fig. 4. Steel Casting for a Herringbone Gear—notice the Large Shrink Heads

Power for rotating the table and for feeding the cutter-heads up and down, respectively, is taken from the main driving shaft which transmits motion to the cutter-arbors. The drive to the table is carried through a differential gear box and thence through herringbone change-gears to two worms meshing with worm-wheels that drive the table. In order to take full advantage of the benefits resulting from the use of herringbone gears, it is of the utmost importance to have extreme accuracy in the spacing of the teeth. Provision is made for obtaining the required degree of accuracy in the spacing of teeth of gears generated on the machines used by the Falk Co. by a patented mechanism that automatically compensates for any error which may exist in the spacing of the teeth of the worm-wheels which drive the table. Means are also provided for taking up lost motion between the worm-wheels and driving worms, so that a degree of accuracy is obtained which appears to be as high as human ingenuity can make it.

Power for the feed motion of the cutter-heads on their respective housings is taken from the table driving shaft and transmitted through the feed box; from this box it is carried back through the differential gear box and thence to the feed shaft which transmits the motion to the lead-screws. This gives the proper relation between the table speed and rate of feed to obtain the required angle for the herringbone teeth of the gear. Change-gears are pro-

Fig. 5. Rough Casting of a Pinion Blank

vided outside the differential gear box to provide for using different hobs, and spiral change-gears are employed to give the proper table speeds for hobbing gears with various numbers of teeth. An auxiliary 7½-horsepower motor is provided for traversing the cutter-heads on the housings when setting up the machine or returning the heads to the starting point after the roughing cut has been completed.

Setting up the Work on the Machine

The gears made on this machine are of the Wuest herringbone type, and it is customary to employ a roughing and finishing cut in generating the teeth. In hobbing gear teeth of the coarser pitches, experiments have been made with roughing hobs having the sides of the thread stepped in a way similar to that employed with stocking cutters on gear cutting machines. This practice has given very satisfactory results. A close view of several teeth of a Wuest herringbone gear is illustrated in Fig. 2, where it will seen that the ends of the teeth at one side of the gear come opposite the spaces at the opposite side.

In setting up the machine for generating a gear, it is obvious that the cutter-heads at opposite sides of the machine must be so adjusted that the hobs are in the proper relation to each other and to the work. A hand-wheel is provided at the end of each cutter-head for the purpose of adjusting the position of the hob in relation to the work. The preliminary setting is made in this way for taking the roughing cut, and after this cut has been completed, a gage is employed for ascertaining the relation of the teeth on one side of the gear to the spaces on the opposite side. This test will generally show that a slight discrepancy exists in the relative positions of the teeth, and before starting to take the finishing cut, the position of one of the cutters must be adjusted so that the finishing cut will result in bringing the ends of the teeth at one side of the gear exactly opposite the spaces on the opposite side.

Casting the Gear Blanks

In addition to its business in the manufacture of gears, the Falk Co. operates one of the most completely equipped steel foundries in the country; and this has placed the concern in an exceptionally advantageous position for manufacturing large herringbone gears, which are generally cut from steel. Figs. 4 and 5 show the rough steel castings; and Fig. 6 shows the finished pair of gears. The gear is said to be the largest ever hobbed from a solid blank; it is approximately 14 feet in diameter by 35 inches face width, and the teeth are of 1 diametral pitch. The pinion is approximately 7 feet in diameter and of the same face width and pitch as the gear; it is made in halves for attachment to the engine crankshaft, and held together by shrink keys. These gears are required to transmit a peak load of 7000 horsepower with the gear running at 30 revolutions per minute. From the illustration of the castings, it will be evident that unusually large shrink heads are provided, the purpose being to supply an abundance of molten metal to feed into the mold as the steel cools and contracts.

After the cutting of the teeth on the gears has been completed, they are set up on a testing machine on which they are "run in" to give the teeth a good bearing surface before the gears are shipped. Large gears are treated with a mixture of oil and emery while they are being run in; and the accuracy of the bearing surface obtained is tested with red lead to be sure that the required degree of accuracy has been obtained in the tooth bearings. In the case of small gears, experience has shown that certain other forms of abrasives give more satisfactory results for the running-in operation.

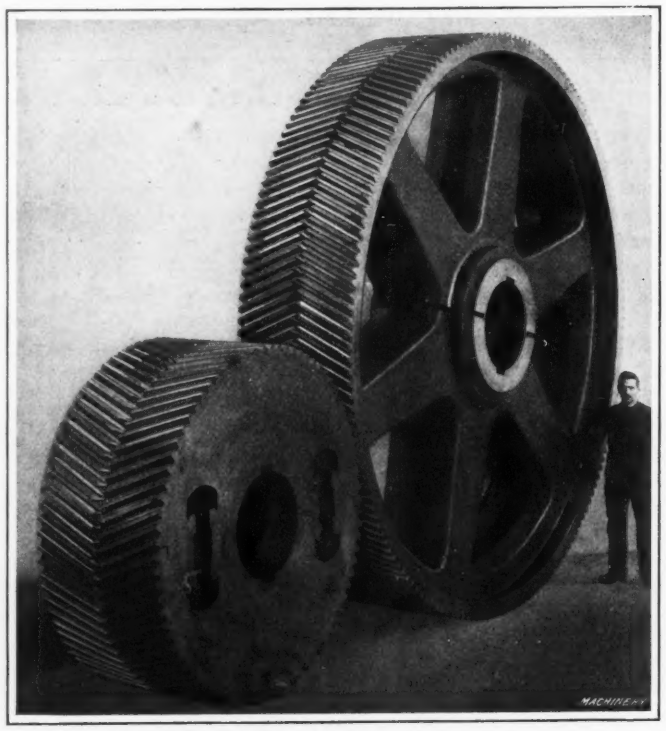


Fig. 6. Finished Pair of Herringbone Gears; Pinion is in Two Pieces connected with Shrink Keys

Advantages of Herringbone Gears

The chief advantage claimed for gears with herringbone teeth is that they transmit the motion with great uniformity, that there is not such a tendency towards the development of wear as in the case of other types of gearing, and that the development of vibration and noise is reduced to a minimum. These features make the application of herringbone gears particularly advantageous for use on all types of machinery where the service is of such a character that the development of shocks or vibration in the gearing is likely to cause the breakage or premature wearing out of machine parts, discomfort to employes resulting from excessive noise, or imperfect work as the result of vibration. Rolling mills used in steel works, heavy-duty pumps of the class employed in municipal pumping stations, and masticators used in rubber factories may be mentioned among the classes of equipment in which the application of herringbone gears

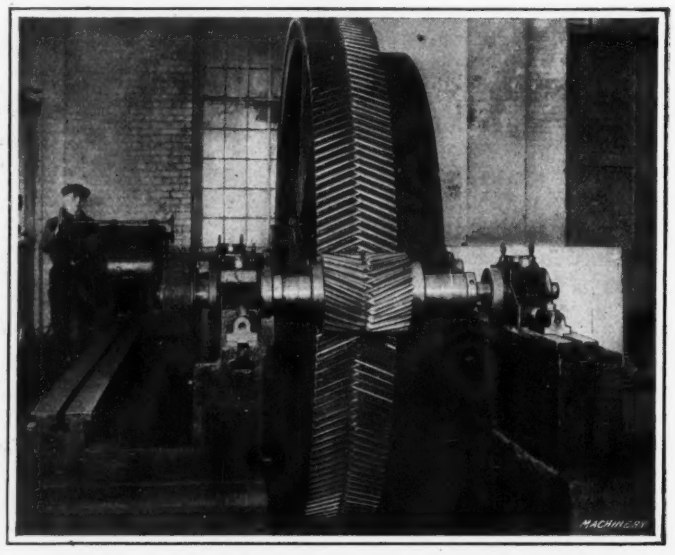


Fig. 7. Running in and testing a Pair of Herringbone Gears

has been a notable success. Advantages resulting from the application of this type of gearing are lost, however, unless a high degree of accuracy is obtained in cutting the teeth. Realization of this necessity led the Falk Co. to improve upon the gear hobbing machines which it has had in use for the generation of Wuest herringbone gears; the machine which forms the subject of this article has now been running for a long enough time to demonstrate its ability to produce extremely accurate work; and in this connection it is noteworthy that accuracy of the product is coupled with an extremely satisfactory rate of production. The operation of the machine is fully automatic and it can be run day and night until the job on which it is working has been completed. E. K. H.

* * *

MATHEMATICS IN ENGINEERING

In an address by Prof. Ernst J. Berg, of Union College, Schenectady, N. Y., before the American Society of Swedish Engineers, at the December meeting in Brooklyn, on "Differential Equations in Engineering" attention was called to the importance of mathematics in many engineering problems which are now solved by "cut-and-try" methods at great expense. It was stated that all real or actual engineering problems can be reduced to such a form that they may be solved by the application of one of six fundamental differential equations. While there are many other mathematical problems leading to differential equations of other forms, these are not of interest to the engineer, as he deals only with things that are *real*, while the mathematician may construct problems that may involve variables of an imaginary character, that is, those that lead to mathematics for mathematics' sake. The engineer, however, is not concerned with these problems, but his problems can all be reduced to six fundamental differential equations that may be said to be the basis of all mechanical and electrical phenomena. The young engineer was advised to acquire the mathematical knowledge necessary to apply and solve these differential equations. Examples were quoted of engineers who had spent a couple of weeks in plotting curves in attempting to obtain some specific engineering information which the mathematician of engineering training had solved in a few minutes. Mention was also made of the fact that the six fundamental equations of engineering apply equally, and have the same form, whether they relate to dynamics in mechanics, to electricity, or to thermodynamics. In fact, the universal laws that underlie all phenomena in physics become apparent first when differential equations are applied to them. Chemistry also has of late been reduced to a mathematical science, and the chemist-mathematician of today can predict with accuracy results that in the past were found only through experiments and careful measurements.

While pointing out that mathematics is by far more important and valuable to the engineer than the average engineer is inclined to believe, Prof. Berg intimated that there was a great deal in mathematics that was entirely useless in engineering, and that it was important to study those things that would find direct application; and the most important of all to the engineer who wants to go beyond the elementary domain of mathematics, is, therefore, differential equations. It was also stated that, with proper teaching, any young man can become a reasonably proficient mathematician, there being no such thing, according to Prof. Berg, as a normal mind inherently unfitted for mathematical studies. He mentioned that in his experience of fifteen years of engineering, and a number of years as professor at the University of Illinois and Union College, Schenectady, he had found young men, who apparently could study mathematics only with the greatest difficulty, but who had, when properly taken in hand, developed into remarkably brilliant students of the subject. He intimated that the average engineering graduate did not know how to use his mathematical foundation, and stated that if he would give an average of fifty hours of concentrated study to the application of differential equations in engineering, using any one of a number of good text-books on the subject, he would acquire a fund of knowledge and a commercial asset which would be worth a great deal to him in increased earning power. While, according to the speaker, mathematics, in itself, was so delightful a study that the trained mathematician would rather read a new good book on the subject than he would a novel, and would read it with the same sense of interest and eagerness, yet the engineer must also look upon the commercial side, and the study of mathematics, when properly applied to engineering, could easily be valued in dollars and cents. Hence, he concluded that all young engineers should take pains to become proficient in the practical application of engineering mathematics.

* * *

RESTRICTED IMPORTATION OF MACHINE TOOLS INTO GREAT BRITAIN

Considerable uneasiness was caused in machine tool trade circles by the publication of a note in the December 6 number of *Commerce Reports*, the daily issued by the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington, D. C., as follows:

> A royal proclamation published November 30, 1915, prohibits, after December 21, the importation into the United Kingdom of all machine tools and parts thereof except small tools. A further exception is made in favor of machine tools and parts thereof imported under the license of the Board of Trade and subject to conditions and provisions of such license.

This statement seemed to be of ominous significance to American machine tool builders, but dealers in England and the Washington authorities made it clear that the British government was simply restricting the importation of machine tools to licensed importers, the aim being to discourage speculation and irresponsible dealings. British importers of machine tools must obtain licenses from the Board of Trade which, in cooperation with the War Munitions Board, restricts the disposition of such articles and regulates profits. There appears to be nothing in the proclamation to give serious uneasiness to legitimate trade interests. It seems to be aimed at the largely speculative trade activity, as pronounced in Great Britain as in America—the business of irresponsible agents or brokers who act as "go-betweens" and play the customer and the manufacturer against each other in order to make fat commissions with little risk. The result of the license requirement will be to concentrate the importation of machine tools into the United Kingdom in the hands of responsible, established machinery dealers.

* * *

PRIMARY MERCURIAL RESISTANCE STANDARDS

The fundamental units of electrical measurement are the ohm, (the unit of resistance) the ampere, (the unit of current) and the volt, (the unit of electromotive force). These units were defined by the International Congress on Electrical Units and Standards, London, 1908, and have since been internationally adopted. The Bureau of Standards, Washington, D. C., has recently issued a publication, Scientific Paper No. 256, dealing with the construction of four standard ohms. This unit was defined by the London Congress as the electrical resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14.4521 grams in mass, of a constant cross-sectional area and of a length of 106.300 centimeters. The Bureau of Standards has constructed four material standards representing the unit in the form of mercury columns in glass tubes. The work involved measurements of the highest accuracy of the length, the departure from uniformity of the cross-section, and the mercury content of each tube, as well as in the comparison with the working standard. All measurements had to be made at the temperature of melting ice prepared from specially purified water which was used in order to avoid any temperature uncertainty due to possible impurities in the ice. Electrical comparisons of the four standards showed the average deviation of their individual value from their mean value to be less than 0.00001 ohm.

HELICAL SPRINGS UNDER CENTRIFUGAL ACTION

SPEED LIMIT DEVICE WHERE THE WEIGHT OF THE SPRING IS AN IMPORTANT FACTOR

BY JOHN S. MYERS*

IN these days of the "Safety First" agitation most high-speed machinery—particularly turbine driven units—is required to be equipped with a speed limit device. Such safety stops are constructed in various ways, but their action usually depends upon a spring being deflected by the centrifugal force of a rotating weight. For low speeds, the centrifugal force of the spring, due to its own weight, is of little moment since it represents but a small percentage of the total weight causing the deflection; but since centrifugal force varies as the square of the velocity, the weight of the spring becomes of considerable importance at even moderately high speeds. For instance, if the spring in a device operating at 1000 revolutions per minute is 5 per cent of the operating weight, a similar device designed to operate with equal force at 4000 revolutions per minute would have an operating weight of $\frac{1000^2}{4000^2} = 1/16$ that of the first weight. The weight of the spring is necessarily as great as before since it must sustain the same load, and hence the spring now constitutes $16 \times 5 = 80$ per cent of the total operating weight. As a result of these conditions, there arises an interesting problem of the influence of the centrifugal force of a spring upon its action. The most usual case of such a device is mathematically

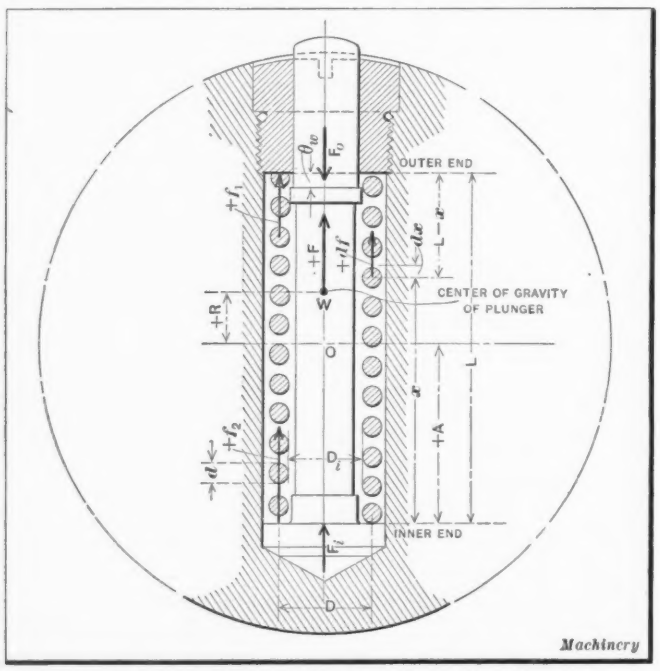


Fig. 1. Safety Speed-limit Device where Spring is acted upon by Centrifugal Force. The Center of Rotation is at O

treated in this article, and as the formulas derived are for the most part general in their form, the same treatment may be applied to other devices where helical springs are subjected to the action of centrifugal force acting in directions parallel to their axes.

Fig. 1 shows the type of device which has been selected for the purpose of making an analysis of the effect of centrifugal force on the action of the mechanism. The following notation is used, all values being in pounds and inches:

W = weight of plunger;
w = weight of spring;
N = R. P. M. of device about center O;
F = centrifugal force of plunger;
f_1 = force at outer end of spring due to centrifugal force of spring;
f_2 = force at inner end of spring due to centrifugal force of spring. (If f_2 is negative in value, it acts toward the inner end of the spring);
K = centrifugal force constant = 0.0000284;
d = diameter of wire from which spring is wound. (Care should be taken not to confuse d used to represent the diameter of the wire with d used to indicate the differential of a variable);
D_1 = inside diameter of coils;
D = mean diameter of coils = $D_1 + d$;
n = number of effective coils, usually taken as the whole number of coils minus 1.5;
F_s = safe load of spring;
θ = deflection of spring;
θ_w = working deflection of spring, *i. e.*, the amount the plunger moves from the inner to the outer position;
P = load required to produce a given deflection of spring under ordinary static conditions, when applied to one end and resisted at the other end;
S = safe transverse stress;
G = transverse modulus of elasticity;
M = modulus of the spring = Pn for $\theta = 1$, *i. e.*, M = deflection per coil, per pound, divided into 1;
L = length of spring in place under its initial strain;
A = distance from center of rotation to inner end of spring, as shown in Fig. 1. If the value of A is negative, it means that the inner end of the spring does not extend beyond the center of rotation. (Since there is ¾ coil on each end of the spring which is dead, the value of L should be reduced from the actual measurements to allow for this condition. The value of A should be similarly reduced, and this ¾ coil at the inner end should be considered as part of the plunger when figuring its weight W and locating its center of gravity. The weight of the spring w should be calculated for the actual number of coils minus 1.5);
R = radius from center of gravity of plunger to axis of rotation;
f = total centrifugal force of spring acting toward outer end = $f_1 + f_2$;
F_1 = force acting on inner end of spring;
F_o = force acting on outer end of spring;
x = distance from inner end of spring to any element of the spring;
dx = infinitesimal element of the variable dimension x;
dw = weight of a portion of the spring having a length dx;
df = centrifugal force of a portion of the spring having a weight of dw.

Safe Load

For the safe load F_s of the spring, we have the following formula:

$$F_s = \frac{\pi d^3 S}{8D} \qquad (1)$$

For small steel springs, 80,000 may be taken as a safe value of the transverse stress S. Substituting this value in Formula (1) we have:

$$F_s = 31{,}416\,\frac{d^3}{D}$$

$$d = 0.0317\,\sqrt[3]{F_s D} \qquad (1a)$$

Deflection

For the modulus M of the spring, we have the following:

$$M = \frac{Gd^4}{8D^3} \qquad (2)$$

For steel we may take the transverse modulus of elasticity G as 11,500,000. Then we have:

$$M = 1{,}437{,}500\,\frac{d^4}{D^3} \qquad (2a)$$

The deflection θ is then found to be:

$$\theta = \frac{Pn}{M} \qquad (3)$$

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Centrifugal Force of Spring

In order to investigate the influence of the centrifugal force due to the weight of the spring itself, we first regard the spring as being without weight and then assign to an element of length dx, a corresponding element of weight dw. Then we construct formulas for the influence of this element of weight and by the methods of the calculus, summate the total effect when all of the spring has been given weight. Following this method of dealing with the problem, we have for the element of weight:

$$dw = \frac{w}{L} dx \qquad (4)$$

The well-known formula for centrifugal force f takes the form:

$$f = KwRN^2.$$

We then have the following formula for the centrifugal force, resulting from the element of weight dw:

$$df = Kdw\ (x - A)\ N^2 = K\frac{w}{L}N^2 dx\ (x - A) \qquad (5)$$

The infinitesimal force df is generated by the centrifugal action of the portion of the spring of length dx, and acts at a point located at a distance x from the inner end, and at a distance $L - x$ from the outer end of the spring. When the value of x is greater than that of A, the force df acts toward the outer end of the spring and is of positive sign. When the value of x is less than that of A, the force df acts toward the inner end of the spring, which will be shown by Formula (5) giving a negative sign. When the force df is of positive sign, it causes compression in that portion of the spring lying between its point of application and the outer end; and tension in the portion of the spring lying between its point of application and the inner end. When df is of negative sign, the converse is true. If the ends of the spring are not attached in such a manner that tension could be transmitted, the development of what would be tension simply reduces the external force on the spring (due to initial deflection or to the force F) by an equivalent amount. It is assumed that there is sufficient initial compression due to the force F so that the amount of any tension developed in the spring can never exceed the amount of compression. The amount of the force df which is sustained at the outer end of the spring is df_1 and it is transmitted over a length of spring $L - x$, through a number of coils equal to $n\left(\frac{L-x}{L}\right)$. Applying Formula (3), this is equivalent to a deflection at the point of application of df equal to:

$$d\theta_1 = df_1 \frac{n}{M}\left(\frac{L-x}{L}\right)$$

The amount of the force df sustained at the inner end of the spring is df_2. This force is transmitted through $n\frac{x}{L}$ coils, and represents a deflection of:

$$d\theta_2 = df_2 \frac{nx}{ML}$$

But these deflections both occur at a common point and hence are equal. Then:

$$d\theta_1 = d\theta_2$$

$$df_1 \frac{n}{M}\left(\frac{L-x}{L}\right) = df_2 \frac{nx}{ML}$$

$$df_1 (L - x) = df_2 x.$$

$$df_1 = \frac{df_2 x}{L - x}$$

$$df_2 = \frac{df_1 (L - x)}{x}$$

Since the force df is divided into two parts df_1 and df_2

$$df = df_1 + df_2$$

$$df_1 = df - df_2$$

$$df_2 = df - df_1$$

Substituting the value of df_2 previously obtained, in the equation for the value of df_1, we have:

$$df_1 = df - \frac{df_1 (L - x)}{x}$$

Clearing the preceding expression of fractions and simplifying, we have:

$$df_1 = \frac{x}{L} df \qquad (6)$$

Substituting the value of df_1 from Formula (6) in the formula for the value of df_2, we have:

$$df_2 = df - \frac{x}{L} df$$

Clearing the preceding expression of fractions and simplifying as far as possible, we have:

$$df_2 = df \frac{L - x}{L} \qquad (7)$$

A minus sign in Equations (6) and (7) would simply indicate that the force df_1 or df_2 acted in a direction opposite to that indicated by the arrows in Fig. 1. Substituting in Formula (6) the value of df obtained from Formula (5) we have:

$$df_1 = Kw\frac{N^2}{L^2}(x^2 dx - Axdx)$$

From the preceding expression, integrating between the limits of L and zero, we have:

$$f_1 = Kw\frac{N^2}{L^2}\int_0^L (x^2 dx - Axdx)$$

$$f_1 = KwN^2\ (1/3\ L - 1/2\ A) \qquad (6a)$$

Substituting in Formula (7) the value of df obtained from Formula (5) we have:

$$df_2 = Kw\frac{N^2}{L^2}(Lxdx - x^2 dx - ALdx + Axdx)$$

From the preceding expression, we have by integration:

$$f_2 = Kw\frac{N^2}{L^2}\int_0^L Lxdx - x^2 dx - ALdx + Axdx$$

$$f_2 = KwN^2\ (1/6\ L - 1/2\ A) \qquad (7a)$$

The sum of f_1 and f_2 should equal the total centrifugal force of the spring f. Hence:

$$f = f_1 + f_2 = KwN^2\ (1/3\ L - 1/2\ A) + KwN^2\ (1/6\ L - 1/2\ A)$$

$$f = KwN^2\ (1/2\ L - A) \qquad (8)$$

In Equation (8) the value of $\frac{1}{2}\ L - A$ is the distance from the center of rotation to the center of gravity of the spring. Hence the formula has the form of the usual one employed for centrifugal force, and thus constitutes a check on the accuracy of Equations (6a) and (7a).

Other Forces Acting on the Spring

When at rest, the load P acting on the spring is that necessary to produce the given deflection, and its value is given by the formula:

$$P = \frac{\theta M}{n} \qquad (3a)$$

When rotating at a velocity sufficient to be operative, the centrifugal forces and the force due to the deflection of the spring must be in equilibrium. In other words, the plunger is floating freely upon the spring, the centrifugal forces being balanced by the condition of the internal stress in the spring. The centrifugal force F of the plunger is given by the following formula:

$$F = KWRN^2 \qquad (9)$$

This is the only external force acting on the inner end of the spring; hence, $F_1 = F$. The internal forces balancing this are P and f_2 and, since f_2 (when of positive sign) acts in a direction opposite to that of P, their combined effect is $P - f_2$. The external forces being equal to the opposing internal forces, we have:

$$F_1 = F = P - f_2 \qquad (10)$$

From Formula (10) the force P acting to produce deflection is seen to have a value of:

$$P = F + f_2 \qquad (11)$$

The total external force F_o acting at the outer end of the spring has a value of:

$$F_o = P + f_1 = F + f_2 + f_1 \qquad (12)$$

Care should be taken to see that f_1 and f_2 have their proper

signs as given by Formulas (6a) and (7a), for, when f_2 is of negative sign we have:

$$F = P - (-f_2) = P + f_2$$
$$P = F + (-f_2) = F - f_2$$

The spring should be made strong enough to safely withstand the action of whichever one of the two forces F_1 or F_o is the greater. To investigate which of these forces is the greater, we know that their difference is $F_1 - F_o$. Substituting and reducing, we have:

$$F_1 - F_o = KwN^2(A - \tfrac{1}{2}L) \qquad (13)$$

From Formula (13) it can be seen that if:

$$A = \tfrac{1}{2}L,$$
$$F_1 = F_o;$$

that if $A > \tfrac{1}{2}L$,

$$F_1 > F_o;$$

that if $A < \tfrac{1}{2}L$,

$$F_1 < F_o.$$

In other words, the longest end of the spring is subjected to the greatest load. Considering the actual load as equal to the safe load, we have for the case where $A > \tfrac{1}{2}L$ (for safety against failure) $F_1 = F_s$. Substituting and reducing to simplest terms, we have:

$$d = \sqrt[3]{\frac{8DKWRN^2}{\pi S}} \qquad (14)$$

For steel, this equation takes the form:

$$d = 0.000967\sqrt[3]{DWRN^2} \qquad (14a)$$

For the case where $A < \tfrac{1}{2}L$, we have (for safety against failure) $F_o = F_s$, from which:

$$d = \sqrt[3]{\frac{8DKN^2}{\pi S}[WR + w(\tfrac{1}{2}L - A)]} \qquad (15)$$

For steel, Formula (15) reduces to the form:

$$d = 0.000967\sqrt[3]{DN^2[WR + w(\tfrac{1}{2}L - A)]} \qquad (15a)$$

Making the constant in Formulas (14a) and (15a) equal to 0.001, for the sake of convenience, corresponds to employing a safe stress of about 72,300 pounds per square inch.

Deflection

Equation (11) gives the value of the force acting upon the spring to produce deflection. Substituting in this equation the value of F and f_2 from Formulas (9) and (7a), respectively, gives:

$$P = KN^2[WR + w(1/6L - 1/2A)] \qquad (16)$$

Substituting this value, together with the value of M from Formula (2), in Formula (3) for the value of the deflection, we have by using a modulus of elasticity G for steel of 11,500,000:

$$\theta = 198\frac{N^2nD^3}{d^4}[WR + w(1/6L - 1/2A)] \times 10^{-13} \qquad (17)$$

Method of Procedure in Designing

The usual method of procedure in designing is as follows: First: decide upon the proportions of the plunger with an assumed size of spring, the working deflection of the spring θ_w, and the variation in the revolutions per minute N to produce this deflection. Second: calculate the weight W of the plunger and the distance R to its center of gravity. Third: calculate the centrifugal force F from Formula (9) for the outer position of the plunger. Fourth: if the distance A from the center of rotation to the inner end of the spring is equal to or greater than ½ the length of the spring L, when in place under its initial strain, then F is the maximum load on the spring. Hence, we either refer to a spring table, calculate the value of the safe load F_s on the spring from Formula (1) and the assumed dimensions, or calculate the value of the diameter d from Formula (14) to insure having a safe size of spring. If the value of A is a considerable amount less than the value of $\tfrac{1}{2}L$, the load at the outer end of the spring must be investigated. To do this, calculate the value of w from the assumed sizes; then calculate the values of f_1 and f_2 from Formulas (6a) and (7a), and the value F_o from Formula (12); then refer to a spring table or calculate the value of d from Formula (15) or (15a). Fifth: being assured of the strength of the spring and having calculated the value of the centrifugal force F of the plunger for the outer position, we proceed to calculate the value of F for the inner position and of the centrifugal force f_2 of the spring

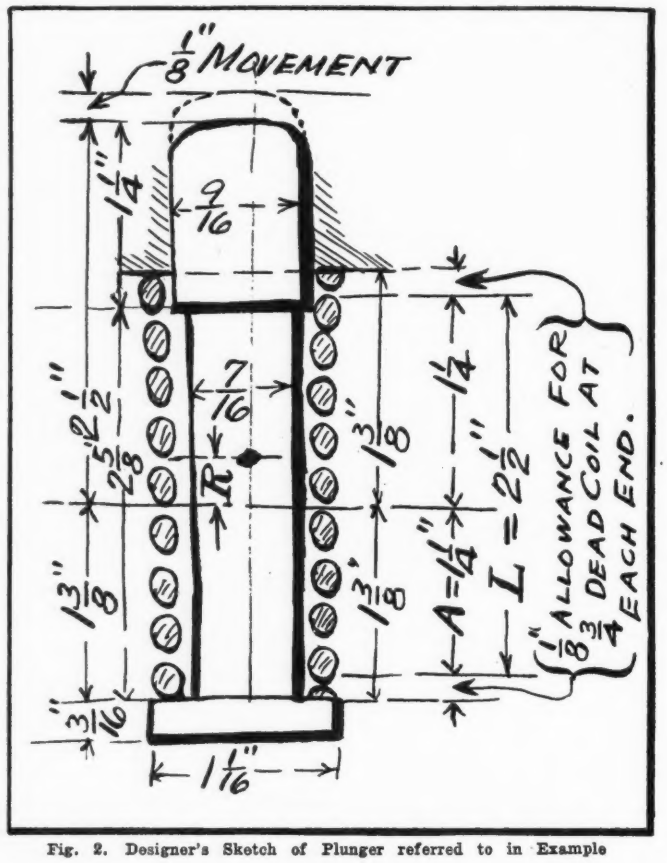

Fig. 2. Designer's Sketch of Plunger referred to in Example

for both positions, by applying Formulas (9) and (7a), respectively. Sixth: substitute these values in Formula (11) for the value of the force P acting to produce the deflection for the inner and outer positions. Substitute these values of P in Formula (3), and if the deflection is not close enough to the desired amount, modify the size of the spring until a sufficiently close value is obtained.

Example

For the plunger illustrated in Fig. 2, we have the following approximate values:

$W = 0.246$ pounds;
$R = 0.365$ inch radius at the inner position;
$R = 0.365 + 0.125 = 0.49$ inch radius at the outer position;
θ_w = movement of plunger = 0.125 inch;
L = actual length of spring when in place under its initial strain = 2¾ inches, or say the effective value of L is 2½ inches. Assume the size of wire for the spring as No. 9 B. W. G. wire;
d = diameter of wire = 0.148 inch;
D_1 = inside diameter of spring = ⅝ inch;
D = mean diameter = 0.625 + 0.148 = 0.773 inch;
N = R. P. M. for inner position = 3150;
N = R. P. M. for outer position = 3240.

Applying Formula (9) for the centrifugal force at the outer position, we have:

$$F = 0.0000284 \times 0.246 \times 0.49 \times 3240^2 = 35.9.$$

For the inner position:

$$F = 0.0000284 \times 0.246 \times 0.365 \times 3150^2 = 25.27.$$

From Equation (1), the safe load F_s on the spring is found to be:

$$F_s = \frac{31{,}416 \times 0.148^3}{0.773} = 131.5 \text{ pounds.}$$

This is apparently a safe value. Assume the pitch of the coils of the spring when in place to be 0.2 inch. Then we have:

$$n = \frac{2.5}{0.2} = 12.5 = \text{number of coils.}$$

The volume of metal in the spring is:

$$\frac{\pi 0.148^2}{4} \times 12.5 \times 0.773 \times \pi = 0.521 \text{ cubic inch.}$$

Then the weight of the spring $w = 0.521 \times 0.283 = 0.147$ pound. For the outer position of the plunger, $L = 2\tfrac{3}{8}$ inches

and $A = 1\frac{1}{8}$ inch. Applying Equation (7a) for the outer position of the plunger we have:

$f_1 = 0.0000284 \times 0.147 \times 3240^3 \times (1/6 \times 2\,3/8 - 1/2 \times 1\,1/8) = -7.3$ pounds.

For the inner position, we have:

$f_1 = 0.0000284 \times 0.147 \times 3150^3\ (1/6 \times 2\,1/2 - 1/2 \times 1\,1/4) = -8.61$ pounds.

Applying Formula (11), we find that the force P producing deflection in the spring is for the outer position:

$$P = 35.9 + (-7.3) = 28.6 \text{ pounds.}$$

For the inner position we have:

$$P = 25.27 + (-8.61) = 16.66 \text{ pounds.}$$

The change in load is thus found to be:

$$28.6 - 16.66 = 11.94 \text{ pounds.}$$

This change occurs for a deflection of $\frac{1}{8}$ inch. For the assumed sizes, for a steel spring, the modulus M is found from Formula (2a) to have the following value:

$$M = 1{,}437{,}500 \times \frac{0.148^4}{0.773^3} = 1490$$

From Equation (3), the number of coils n is found to be:

$$n = \frac{\theta M}{P} = \frac{0.125 \times 1490}{11.94} = 15.6 \text{ active coils, or } 15.6 + 1\frac{1}{2} = 17.1 = \text{ total number of coils.}$$

The length of the spring when completely compressed to bring it coil to coil would be:

Length of spring equals $17.1 \times 0.148 = 2.53$ inches.

Length of spring with plunger out $= 2\frac{5}{8}$ inches.

The sum of the clearance between the coils is thus seen to be $2.65 - 2.53 = 0.095$ inch, and the clearance per coil is $0.095 \div 17.1 = 0.00556$ inch.

The number of coils, as previously calculated, is $\frac{15.6 - 12.5}{12.5} \times 100 = 24.8$ per cent greater than the assumed number upon which the weight of the spring was based; and the value of f_2 is consequently 24.8 per cent greater, thus reducing the effective value of the force P. The clearance between the coils is also too small to allow of sufficient adjustment, so that the design of the spring or plunger should be slightly modified to meet these conditions. By recalculating with new assumed sizes, the resulting error should be extremely small.

* * *

ALUMINUM DIE-CASTING*

None of the die-casting alloys in general use, such as zinc, tin or lead base, exceed cast iron in tensile strength. It can therefore be seen that the foundation of the die-casting industry is based on economy. The cost of any die-casting must be less than the combined cost of producing that casting in cast iron and machining to a finished product equivalent to a die-casting. The cost of metal is a vital factor to the life of the die-casting industry, as prohibitive prices for raw materials must exclude die-casting from competition with other methods of production. The zinc market will serve as a good illustration. In 1914 approximately 85 per cent of the die-castings produced were made from zinc alloys consisting of a minimum of 85 per cent zinc, the other elements being tin and copper, which having a higher market value tend to raise the net cost of the average zinc die-casting alloy to approximately 5 cents a pound above the market price of zinc. For example, with zinc at 7 cents, copper at 16 cents and tin at 40 cents, which prices are about average, the cost of the average die-casting alloy is 12 cents a pound. This means that in order to compete with sand-casting the die-casting process must show a minimum saving of about 9 cents a pound on the machining cost of the casting since the cost of cast iron does not exceed three cents a pound. The cost of zinc, intermediate brand, on June 1 was 28 cents a pound which would bring the cost of the average die-casting alloy up to 31 cents per pound.

What this high metal-cost means to the die-casting industry can readily be understood by considering the fact that in order to compete, a three-pound die-casting must show a net saving on machining cost of at least 84 cents. Although there are numerous instances where die-castings show a saving even at this high price, the growth of the industry must of necessity be curtailed if such conditions are to prevail, unless a substitute for zinc is found. A careful study of the properties of the common metals reveals aluminum as the "hope" of the die-casting industry. The normal price of aluminum before the war was 8 cents which, considering the specific gravity, makes it the cheapest non-ferrous metal, and with aluminum at 35 cents a pound it exceeds only lead in cost.

The Doehler aluminum die-casting process, patented by H. H. Doehler, is the first that has been developed on a commercial basis in America or other countries. This process is no longer an experiment, having been in operation for more than two years, during which time castings have been turned out for use on many of the high-priced automobiles and other machines. At the present time, 150,000 pounds of aluminum are being converted into die-castings each month by the Doehler process. The alloy used in this process is aluminum copper, which term means that the alloy contains no tin, zinc or cadmium. The exact components of the alloy will not be published until the patents are granted.

The aluminum die-casting, although a commercial proposition, cannot economically replace zinc alloy die-castings where the latter are satisfactory, despite the lower cost of the aluminum alloy for the same bulk. The cause for this which, in fact, is the most serious drawback to the expansion of the industry lies in the life of the dies. A die for a zinc alloy casting will last almost indefinitely, whereas with aluminum alloys the best die material obtainable will not produce over 5000 castings without heat checking. Thus it will be readily seen that it must add largely to the cost of the casting if a new die is to be made for every 5000 castings.

* * *

"AMPCO" BRONZES

The illustration shows a rude cold chisel made of "Ampco" bronze, which when used for chipping machinery steel held an edge as well as some chisels made of tool steel. These bronze chisels are being sent to the trade by the American Metal Products Co., Milwaukee, Wis., more as a curiosity, of course, than as practical working tools. They are intended to show some of the remarkable properties of "Ampco" hard bronze. Though not offered as a substitute for tool steel, it is claimed that this bronze in the form of cutting tools will serve not only as cold chisels but as lathe tools for turning

Cold Chisel made of "Ampco" Bronze, that cuts Iron and Steel

iron, mild steel and softer metals. It cuts aluminum without the use of a lubricant.

This bronze, which is furnished in different grades, contains no tin, zinc, lead or phosphorus and is non-corrodible, resisting diluted and strong sulphuric, hydrochloric and various organic acids, strong solutions of alkali carbonates and caustic alkali, sea water, various salt solutions, atmosphere, etc. It is cast in sand successfully and may be die-cast in iron or steel molds without causing rapid deterioration of the molds. In this respect, it differs radically from other brasses and bronzes containing tin, copper and zinc. Tin and zinc attack iron and steel at high temperatures, forming alloys with the iron, and soon destroy the interior of iron and steel molds. It is claimed also that this bronze has the advantage of being very strong at high temperatures and is thus better able to withstand cooling stresses than ordinary bronzes used in die-casting. "Ampco" bronzes are furnished chiefly for bearings. Because of their hardness, it is claimed that their wear-resisting quality and frictional resistance is low. They are about 18 per cent lighter than brass, and annealing has no effect on the hardness.

* Abstract of paper read by Charles Pack at the annual meeting of the American Institute of Metals, September 28 to October 1, at Atlantic City, N. J.

OXY-ACETYLENE WELDING PRACTICE*

THE WELDING OF SHEET METAL AND BOILER WELDING BY THE FUSION WELDING METHOD

BY S. W. MILLER†

SHEET metal is used in so many different forms and for such a variety of purposes that it is impossible to give any specific directions in regard to the methods to be followed in welding it. However, some general points can be noted, and the application to specific cases can often be derived from them. It should never be forgotten that in any welded piece there are likely to be strains due to contraction and expansion caused by the heating. In the case of brittle metals, such as cast iron, this strain will probably manifest itself by the piece cracking at some time during the operation or afterward. In the case of tougher metals, such as steel, the strain may not and probably will not so manifest itself, but it will be found instead that the piece will become distorted. The same general principles for taking care of strains in brittle metals apply in the case of tough metals. In other words, contraction must be allowed for in some way, either by preheating, separating the parts, or by expanding some part of the piece by heat or power, etc.

If a piece of steel plate ⅛ inch thick and 6 inches square be heated red-hot in the center with a torch, no particular change will be noticed during the heating, but on cooling off, while no crack will occur as it would if the plate were made from cast iron, the sheet will become badly warped. This warping can be remedied, as is done in every-day practice in boiler or tank shops, by laying the plate on an anvil or solid block of iron and peening it with a hammer until it is straight. This is an operation that requires considerable skill and experience, and is brought to its highest development probably in the case of large circular and band saws used for cutting wood. These have to be "hammered" to suit the speed at which they run and the conditions under which they operate. Without some experience, an attempt to straighten such a piece of steel will result in making it worse than it was originally, and while this process can be used, it is desirable to avoid it if possible. In the case of a small sheet, much of the difficulty can be overcome by heating it red-hot before welding, but in the case of a large sheet, this practice is not feasible, and it is generally difficult, if not impossible, to weld it neatly at the center. However, it is seldom necessary to make such an attempt, the majority of sheet welding being done along the edges, or in other places where the expansion due to the heating can be more readily controlled.

The welding together of short pieces of thin steel may be frequently accomplished nicely by preheating the whole piece along the edges to be welded. If there are many pieces of one kind to do, it will pay to make an arrangement by which a gas burner can be kept under the weld while it is made. In such cases the weld may be tacked at several points along the edges, and if it is kept red-hot by the gas flame it will give very little trouble, and in many cases the distortion will not be sufficient to cause any difficulty. On the other hand, in repair shops, it is not often that many pieces of one kind are done, it being generally odd jobs that are received. In cases where the weld is long, the best plan is to separate the sheets at one end by an amount equal to about 2½ per cent of their length, and just bring them together at the other end. If it is found that the contraction of the weld pulls the sheets together too fast, it will be necessary to hold them apart by clamping, wedging or some other method, forcing the contraction to take place in the weld rather than allowing the sheets to be pulled together. If, on the other hand, the sheets do not come together fast enough, stopping the welding process for a short time will generally correct the trouble, as the sheets cool off and do not again regain the same amount of heat.

It is not possible to clamp thin sheets so tightly that the edges may be brought absolutely together and all the contraction forced to take place in the weld. Even with very powerful clamps it is practically impossible to obtain the same pressure at all points along the edges, and, of course, where the pressure is less the contraction will be greater, the result being a buckling of the sheet and a wavy appearance on finishing the job. One of the easiest ways on odd jobs of this kind is to put a cross of ½-inch round metal between the sheets a considerable distance ahead of the torch, advancing it or moving it back from time to time as the contraction of the weld warrants. This of course has its limitations, because when the sheet is very thin, it will bend rather than force the contraction to take place in the weld; but if the sheets are ¼ inch thick or more, it is very satisfactory, particularly if clamps be placed across the sheet in several places, to keep the edges in line vertically.

Another objection to the use of clamps is that unless carefully designed, it is impossible to obtain the same pressure on the sheets twice in succession, and if it is found that a certain pressure with a certain amount of opening at one end will answer the purpose, it is evident that less pressure will cause the sheets to come together too fast and *vice versa*.

In the case of very thin material, such as is used for steel doors in railway passenger equipment, many ingenious jigs and clamps have been devised to hold the parts absolutely in line while welding. They all operate on the principle of forcing the contraction to take place in the weld. As they are special for each type of door manufactured, and as they are too expensive and generally not applicable for repair welding shops, no attempt is made to give any details of their construction, it being sufficient to say that the results obtained by their use are exceedingly satisfactory, and good results could not be obtained without them.

The methods outlined are applicable not only to flat sheets, but also to longitudinal seams of tanks such as range boilers, oil barrels, etc. In many cases automatic welding machines have displaced hand work on such articles and give a regularity of welding, uniform quality and appearance that is not obtained by hand welding. Light sheet welding by hand is really a special trade. The welder must have a steady hand and must keep in continual practice. While such welds made by an ordinary welder would appear to him very regular and uniform, they would seem to the expert sheet welder rather rough and irregular, although they might be perfectly sound. Such welds, if properly made, require very little finishing and result in as smooth a surface after grinding as the original sheet, and also have no buckling or other defects. The thicker the sheet is, the less is the trouble from buckling, and it is generally possible to make a nice appearing and sound weld in such sheets by keeping the wedge of metal between the sheets some distance ahead of the torch as previously explained.

Welding Copper and Aluminum Sheets

The welding of sheets of flat metals other than steel is only done in exceptional cases, and while the same principles apply, other metals are generally more ductile, and the strain can be more readily taken care of. It should not be forgotten that all such welds are castings, and except in the case of aluminum, the weld will not be as strong, nor can it be hammered or otherwise worked as safely as the original sheet. Pure rolled sheet aluminum or aluminum sheet with but little alloy can be welded with excellent results, if a satisfactory flux is used, and the resulting weld will be as malleable as the original sheet. Such work is done every day in the case of carriage and automobile bodies, and the metal is afterward beaten over the forms without any difficulty. In the case of copper and brass, proper annealing will help the brittleness of the weld very much, but this cannot always be done, and therefore care should be exercised in subjecting the weld to hammering, rolling, etc.

* For information on oxy-acetylene welding practice previously published in MACHINERY, see "Oxy-acetylene Welding Practice," November, 1915, and articles there referred to.

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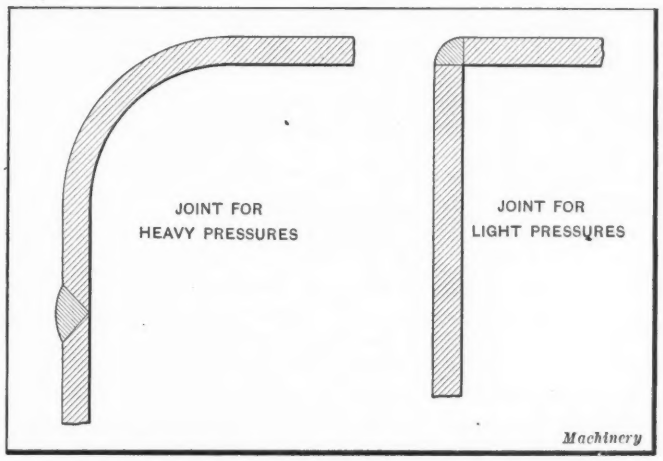

Methods of making Joints for Heavy and Light Pressures

Welding Heads of Tanks

In the manufacture of steel tanks, there is no special difficulty in welding in the heads. There are, however, a number of precautions that should be observed in the preparation of the pieces, the principal one of which is that they should be so designed as to avoid anything except tensile strain in the weld; that is, no design should be made in which there is any chance of a bending strain occurring due to internal or external pressure. Two examples are given in the illustration showing good construction, and as these are economical as well as safe, it is not necessary to show examples of objectionable ones, it being safe to assume that constructions other than those shown will not give as good results. There are two principles to be followed in making such joints: first, that the included angle of the V should be at least 90 degrees; second, that the sum of the edges of the V should be as short as possible. Modifications of these principles may be allowable in special cases, but for all ordinary work they should be strictly followed. In making any welds in tanks subjected to pressure, care must be taken to have the weld made entirely through the sheet, so that there is no crack or remnant of the original edges of the sheet left unjoined.

Boiler Welding

The welding of boiler sheets is really a specialty, and should not, except in the simplest cases, be undertaken by a repair shop, unless the welder or the person in charge is thoroughly familiar with boiler construction and the ordinary repair methods. So much depends on the soundness of a boiler that only the very best work is justifiable. Such work can only be obtained from a thoroughly honest, competent welder, who will at all times do the best that lies in his power. Sound welds, free from burnt and oxidized spots and slag, cannot be obtained, even by the best welder, without a good torch; and for this work the best is none too good. It is also almost necessary that the person in charge of the shop be familiar with boiler construction and repairs, so that he, being responsible, may decide intelligently what is to be done, and how.

For these reasons, Henry Cave has proposed what he calls the "three license system," for boiler welding, by which the proper authorities would license the plant doing the work, the apparatus to be used, and the men actually doing the work, after proper examinations and tests had been made. There is much to commend this plan, although the details would have to be worked out carefully. It would appear that if those in charge of the operation of boilers are compelled to obtain a license for the protection of the public, those making repairs should also be compelled to adopt similar "safety-first" methods. The author believes that, in addition, the moral character of the welder should be carefully looked into. A man who drinks or dissipates has no moral right to make a boiler weld, as all the welder's facilities must be on the alert. It is difficult to obtain men with just the right qualities, of course, but it is not by any means impossible.

For such shops as are equipped to do this kind of work, the rules of the Federal government in connection with marine inspection, are an excellent guide as to what may be undertaken in the present state of the art. These rules are, of course, conservative, and in the case of marine work, must be closely followed. The Federal rules are given in the "General Rules and Regulations prescribed by the Board of Supervising Inspectors," copies of which may be obtained at any of the local officers of the Inspection Department, or from the Department of Commerce at Washington, D. C.

The boiler insurance companies must be consulted about the work contemplated in all cases when insurance is carried, as their inspectors would reject it unless the work met with their approval, and the insurance would lapse. As a matter of self-protection, a repair shop should be cautious about boiler welding, because if anything happened later to the boiler, even though it were not the fault of the welding, serious injury might result to the reputation of the shop doing the work.

On the continent of Europe, much greater progress has been made in the welding of boilers than in the United States, and much work is done there that is not yet permitted here. Hence, there is a vast field open to those who are willing to take the time and make the effort to become accomplished welders in this line.

The technique of boiler welding, except in the case of a few specialists is not yet developed to the point where any one except such specialists should make welds in sheets where the working stress is entirely tensile, such as the shell of any boiler or the roof sheet of a locomotive type boiler. Even the most competent welders, in the author's opinion, should never touch such places, because a crack there points very strongly toward poor design, unsatisfactory material, old age, or overstrain, especially if the defect is near a longitudinal seam and this seam is a single or double riveted lap joint.

There is probably no other important mechanical structure in which more accurate knowledge exists as to the actual stresses involved, and as to the strength of the various joints used than in boilers. This knowledge, however, is unfortunately not as widely disseminated as it should be, and the lack of it (and in some cases the desire to build boilers as cheaply as possible) has resulted in construction that is not good and is sometimes dangerous. These cases are not so common as they used to be, with the result that modern boilers generally give little trouble from defects, unless the boilers are badly treated, or carelessly repaired.

The chance of being called on to make repairs to a boiler, therefore, is generally in the case of one that is rather old. Under these conditions the author always makes a careful examination and if he thinks the boiler is unsafe, he refuses to do any welding at all on it. It is a safe plan for the owner of a defective boiler to have it inspected by one of the boiler insurance companies; and if they will insure it after the welding is done, of course the work can be proceeded with. If they will not insure it, the repairs should not be done.

Simple Boiler Repairs

There are a number of simple boiler repairs that can be readily made, in which the strength of the boiler is not particularly involved, such as welding flue sheet bridges, fire cracks in seams from the rivet holes to the edge of the sheet, etc. In all cases a V should be made entirely through the sheet, leaving the bottom of the V open at least 1/16 inch, so that the metal can be welded from the bottom up. The dirt and scale should be well cleaned off the inside of the sheet as well as the outside. It should not be forgotten that lime or any similar form of scale tends to make a brittle weld. Where one sheet laps over another, as in the case of a fire crack in a seam, the edges of the crack should be raised after beveling by heating somewhat with the torch and driving a chisel underneath. This permits of the weld being made entirely through the sheet. In taking care of the contraction after such work, great reliance can be placed on hammering of the weld just after it is made, to expand it, and in fact it is the only simple way with which the writer is acquainted. The hammering must not be continued too long, that is, below a blue heat, or the tendency will be to produce a crack.

Of course fire cracks and broken flue sheet bridges mean

short welds, and there is very little chance of leaving a strain in those cases. Where the weld is longer, much judgment must be used in hammering to avoid producing serious strains which may later result in cracking the sheet. Again, there are cases where sheets are corroded in spots. These can generally be built up with perfect safety and to good advantage. Frequently an expensive replacement may be avoided by doing this. However, in such cases, there will undoubtedly be a loosening of the rivets if there are any in the vicinity of the work, and these will have to be replaced or calked to overcome leaks. In some cases it pays to cut out the rivets and redrive them after the welding is done.

Another frequent and rather easy repair is the adding of sufficient metal to a worn calking edge to permit of the sheet being recalked. This can easily be done without welding to the sheet underneath. After the welding is done, the metal may be hammered down and chipped and calked as in the original construction. A small patch can be applied in the corner of a firebox quite readily, but the rivets should be removed for a distance of 8 or 10 inches to allow for contraction.

In a general way there is but little difficulty from contraction in doing welding where there is a change of direction in the surface of the sheet, for example, near a flange or similar bend, because by removing a few of the rivets, the contraction takes care of itself and the rivets can generally be replaced easily. However, in the case of a flat sheet, the problem is entirely different. The welding of cracks in fire-boiler furnaces or fireboxes requires a high degree of skill and knowledge, and generally necessitates the use of special appliances for confining the heat to a narrow zone. Such cracks do not develop singly, but are accompanied by parallel cracks for quite a distance along the sheet. These are frequent in locomotive boilers, and are due to the fact that under severe service the water is driven away from the sheets so that they become overheated. When they are hot, the pressure in the boiler tends to bulge them, causing cracks to appear on the fire side between the vertical rows of staybolts, and on the water side through the centers of the staybolt holes. In the course of time one of these cracks goes through and begins to leak. While there may be no evidence of any more cracks, the bulging of the sheet indicates that there are at least incipient cracks beside the one giving the trouble. Now if the leaky crack be welded, the shrinkage of the weld will open up one of the cracks somewhere in the vicinity, the weld being stronger than the rest of the sheet.

Instances have been cited where a large number of cracks of this kind were welded in one firebox, the result being that finally there was a considerable gap in the last crack that developed, this being, of course, approximately equal to the sum of the shrinkages of the welds. In such a case it may be possible to weld a crack, but the writer does not believe it advisable except for temporary purposes, and then with the distinct understanding that the job is not sound and further trouble will undoubtedly result.

In order to take care of the contraction, it is sometimes the practice to run streams of water or compressed air on the sheet on each side of the crack, about 4 inches from it, thus preventing to a large extent the expansion due to the heat of the torch and reducing the contraction.

The highest development of the welder's art is needed in the application of patches in the center of a stayed surface, such as a side or flue-sheet of a locomotive firebox. There is no particular difficulty about welding the first side or even the second, but the trouble comes on the third and fourth, particularly on the last one. It is always necessary to use a box patch, that is, one that is dished in the center, so that the dishing will take the strain. Such work, as well as the application of entire side sheets, and patches 12 feet long in large fireboxes, are perfectly possible, and in fact are done every day in locomotive boiler shops, but they are the work of men who are trained in that direction, and they should never be done by any ordinary welding shop. It is therefore unnecessary to give any detailed description as to how this work should be attacked, particularly as the appliances for doing it are special, and have to be modified to suit each case. There is one thing, however, that should always be done in case of any work inside a boiler, or other confined space. An extra man should be stationed at the tanks, which should always be kept outside of the space or boiler, so that in case the hose bursts and the acetylene catches fire, it can immediately be shut off, thus avoiding possible fatal injury to the men inside.

* * *

DIFFICULTIES OF SCIENTIFIC MANAGEMENT IN SMALL PLANTS*

The factory employing from a hundred to three hundred men is frequently owned by a single individual, or, if the company is incorporated, the management is dominated by the heaviest stockholder to such an extent that the result is the same. This man may not be actively engaged in the business of manufacture—quite frequently he is not—but nevertheless his influence is strongly felt in matters touching the general business policy, expenditures, and innovations of any sort.

The manager of the business, who may or may not have had manufacturing experience, is often the sales manager, in fact, if not in name, and presides over the general office of the company. He is looked to for results, but must keep well within the limits of the company's policy as laid down according to the doctrines of the dominant stockholder, and heresy of any kind on his part is likely to result in personal disaster.

One of the most firmly established tenets in the creed of the successful business man is that of insisting upon the utter extermination of unproductive labor. No one will dispute the soundness of the reasoning, provided the labor so designated assists in no way the process of manufacture. Too often, however, since the man whose brain only is active differs not greatly in appearance from the man who is loafing, the fact that an employe is neither rushing about nor actively engaged in manual labor causes him to be condemned as useless, and he is henceforth abolished. The heavy stockholder very often knows a good deal about bookkeeping, and, since he visits the factory to better it, he will readily attack any apparent excess of men in this department, while fear of showing his ignorance would cause him to hesitate a long time before criticising the number of men actually engaged in the work of manufacture. The manager and the superintendent must please their superior and so are extremely loth to sanction in any way an increase in "apparent unproductive labor." When lack of profits forces retrenchment, the clerical force is always the first to be attacked, and the efficiency of the executive is often badly impaired by the consequent lack of necessary assistants. Even some very successful business men go so far as to view with great alarm the acquisition of anything in the nature of office furniture by a superintendent, fearing that he may be tempted to loll in idleness when he ought to be rushing about among his men. They feel that they are getting their money's worth when he is wearing out shoe leather which he pays for himself, but they are not so sure of it when he is sitting at a desk working his brains and using paper and pencil which they pay for. This may seem to be an exaggeration, but nevertheless the two commonest criticisms applied to managers and superintendents are, "the business is too top heavy," or, "he has too many men standing around."

Human nature being what it is, and the successful owner having pretty definite ideas as to who is responsible for his success and as to just how it was obtained, what chance has the efficiency engineer of foisting upon the average small business the paraphernalia of staff and line, routing, dispatching, and time study, with their chief of staff, supervisors of study, of planning, of standards, of bonus, of analysis, etc., together with each one's clerks, messengers, etc.? How, then, is the small- or medium-sized enterprise to obtain the benefits which can unquestionably be obtained by the introduction of the principles of efficiency? That is the question.

* * *

It may take time to be careful, but it takes more time to look after injuries.

* From an article by Dwight T. Farnham in the "Engineering Magazine," October, 1915.

DESIGN AND CONSTRUCTION OF SPROCKETS*

IMPROVEMENT IN EFFICIENCY RESULTING FROM DETERMINATION OF SPROCKET DIMENSIONS BY EXACT MATHEMATICAL INVESTIGATION

BY B. D. PINKNEY†

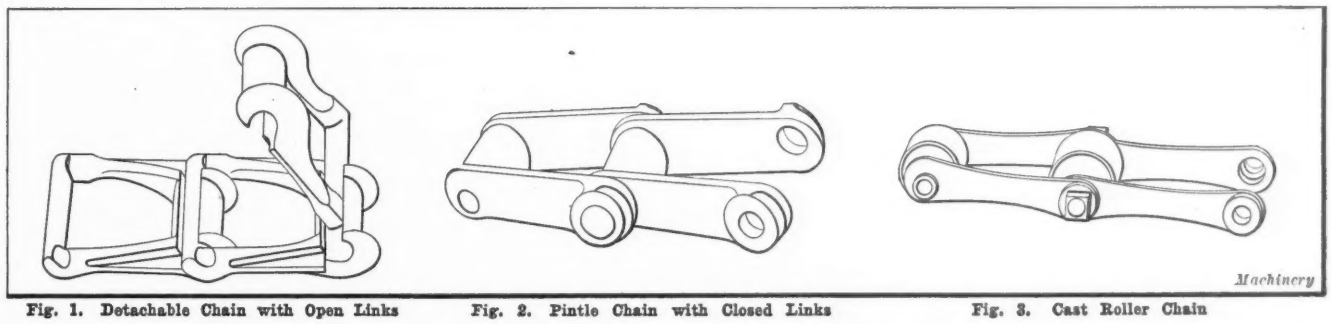

Fig. 1. Detachable Chain with Open Links

Fig. 2. Pintle Chain with Closed Links

Fig. 3. Cast Roller Chain

THE design and construction of sprockets, especially cast sprockets to carry chain of those pitches for which cutters are not regularly made, is an important branch of machine building. The design of such sprockets is generally carried out by cut-and-try methods without reference to geometrical construction or the use of rational formulas. The accuracy of sprockets designed in this way is more or less questionable, and they are only suitable for comparatively low speeds. The inaccuracy of the earlier types of cast chains was probably responsible for the adoption of this method of designing; but with the advent of the closed-link or pintle chain, and also the greater accuracy of the modern open-link or detachable chain, the lack of uniformity was reduced to such an extent that the development of rational formulas for the construction of sprockets for such chains became a mechanical necessity.

It is my intention to show that the design of sprockets lends itself readily to exact mathematical investigation; and that the combination of sprockets designed in this way, with a modern cast chain of accurate dimensions, naturally results in the production of a marked increase in the efficiency of the drive. Cast chain is divided into three general types, *i. e.*, detachable chain (open links) shown in Fig. 1, pintle chain (closed links) shown in Fig. 2, and roller chain shown in Fig. 3. The cast block chain shown in Fig. 4 is of the pintle type; and the chains shown in Figs. 5 and 6 are machined with great precision. Standard cutters are now made for machining sprockets, and the formulas for use in designing cast sprockets apply equally to sprockets with machined teeth.

In the early stages of the manufacture of detachable chain, which was invented in 1873 by W. D. Ewart, the lengths of equal numbers of links varied considerably, *i. e.*, the pitch was not constant. Neither did the links work together with a degree of satisfaction that would warrant their indiscriminate use; and the chain, when used for transmission purposes, could not be made to work satisfactorily on a sprocket of uniform base diameter, if the sprocket had to be used both as the driver and the driven member.

In the year 1882, W. D. Ewart invented a sprocket with an improved tooth base, and one of his patent claims was for "a sprocket-wheel having the roots of the teeth of different depths at their opposite sides, so as to produce a differential pitch according to whichever of said sides may be made the working sides of the teeth." This sprocket is shown in Fig. 7. The driving sprocket, by putting the chain in tension, took up all lost motion in the links and made the chain of greater pitch, so that the chain would accommodate itself to the greater base diameter of the sprocket. The smaller base diameter was for a normally slack chain on a driven sprocket. Mr. Ewart, in his patent specifications, describes this as a novel construction "whereby wheels cast from the same pattern may be used as either driving wheels or driven wheels." As modern cast chains closely approach the accuracy of machined chains this differential feature is no longer necessary, and manufacturers have abandoned its use. Driving sprockets and driven sprockets are now made of exactly the same diameter.

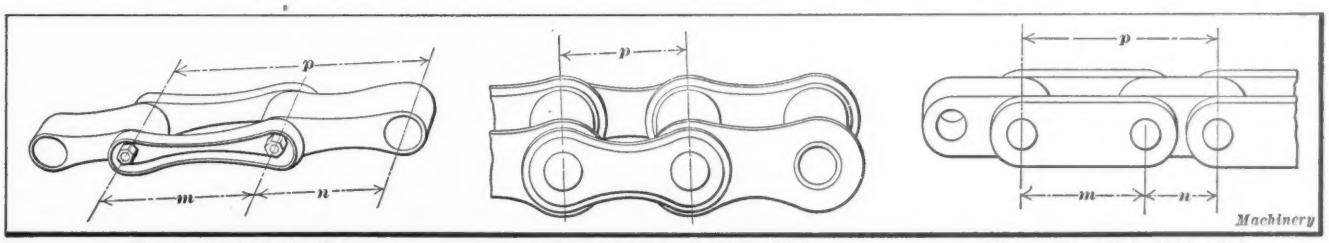

Fig. 4. Cast Block Chain

Fig. 5. Machined Roller Chain

Fig. 6. Machined Block Chain

* For other articles on the design of sprockets, chain-drives and allied subjects published in MACHINERY, see "Calculations for Roller Chain Drives," March, 1914; "Standard Sprockets for Detachable Link Belts," August, 1913; "Selecting the Number of Teeth for Gears and Sprockets," September, 1912; "Design of Dished Sprockets," October, 1911; and "Roller Chain Power Transmission and Construction of Sprockets," February, 1905.

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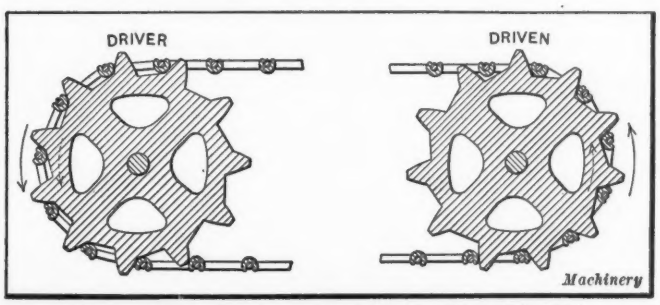


Fig. 7. Ewart Sprocket with Patented Differential Pitch

TABLE I. PITCH OF DIFFERENT SIZES OF SPROCKET CHAINS

No. of Chain	Average Pitch, Inches	No. of Chain	Average Pitch, Inches
25	0.902	77	2.293
32	1.154	78	2.609
33	1.394	83	4.000
34	1.398	85	4.000
35	1.630	88	2.609
42	1.375	93	4.033
45	1.630	95	3.967
51	1.155	108	3.075
52	1.506	108	4.720
55	1.631	110	4.720
57	2.308	114	3.250
62	1.654	122	6.050
66	2.013	124	4.063
67	2.308	146	6.150
75	2.609	...	.....

Machinery

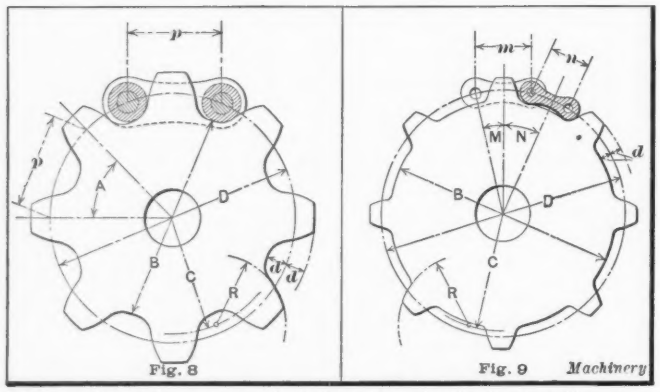


Fig. 8 Fig. 9 *Machinery*

Figs. 8 and 9. Diagrams used in deriving Formulas for Sprocket Diameters

Until a few years ago, the chain manufacturers gave the pitch of detachable chains in terms of an approximate number of links per 10 feet, and chains of equal length rating varied as much as 2 inches in 10 feet. Now that a greater degree of accuracy has been established, the average pitch of the chain is given. Table I gives a list of the "engineering detachable chains" which are extensively used in machine construction, together with their average pitch. But the important factor in sprockets is the base diameter, and not the pitch diameter, although the pitch diameter must first be calculated, after which the base diameter is determined from the measurement of the chain dedendum. The pitch diameter of sprockets is found by Formula (1), and the pitch diameter of sprockets for block chains is found by Formula (2):

$$D = \frac{p}{\sin \frac{1}{2} A} \qquad (1)$$

$$D = \frac{m}{\sin M} \qquad (2)$$

TABLE II. CONSTANTS FOR USE IN DETERMINING SPROCKET DIAMETERS (SEE FIG. 8)

No. of Teeth	Constant k	No. of Teeth	Constant k	No. of Teeth	Constant k
5	1.7013	25	7.979	45	14.336
6	2.0000	26	8.296	46	14.654
7	2.3047	27	8.614	47	14.972
8	2.6131	28	8.932	48	15.290
9	2.9240	29	9.249	49	15.608
10	3.2360	30	9.567	50	15.926
11	3.5490	31	9.885	51	16.244
12	3.8640	32	10.202	52	16.562
13	4.1790	33	10.520	53	16.880
14	4.4940	34	10.838	54	17.198
15	4.8100	35	11.156	55	17.517
16	5.1260	36	11.474	56	17.835
17	5.4420	37	11.792	57	18.153
18	5.7590	38	12.110	58	18.471
19	6.0760	39	12.428	59	18.789
20	6.3930	40	12.746	60	19.107
21	6.7100	41	13.064	..	.....
22	7.0270	42	13.382	..	.....
23	7.3440	43	13.700	..	.....
24	7.6610	44	14.018	..	.....

Machinery

$$\tan M = \frac{\sin N}{\frac{n}{m} + \cos N} \qquad (3)$$

where D = pitch diameter;
p = pitch of chain;
$m + n = p$.
For A, M and N see Figs. 8 and 9.

For conveniently finding the pitch diameter of any sprocket of 5 to 60 teeth, reference may be made to either Table II or Table III. Merely multiplying the constant k by the pitch of the chain gives the pitch diameter of the sprocket. For instance, the pitch diameter of a 35-tooth sprocket for No. 75 chain is:

$$11.156 \times 2.609 = 29.106 \text{ inches.}$$

The base diameter B (see Figs. 8 and 9) is obtained by Formula (4):

$$B = D - 2d \qquad (4)$$

As the manufacturers of cast chains do not give the dimension of the dedendum d, it must be measured from the chain. Machined chain manufacturers always give this dimension. Fig. 10 shows the construction of the sprocket teeth.

$$\text{Radius } C = 0.47\,D \qquad (5)$$

$$\text{Radius } R = 0.17\,D \qquad (6)$$

If radius R is less than $p - d$, use a minimum radius according to Formula (7).

$$\text{Radius } R \text{ (minimum)} = p - d \qquad (7)$$

$$W = 0.8\,L \text{ (except for roller chain)} \qquad (8)$$

The tooth width may be constructed as shown in Fig. 11 if the sprocket is of the webbed type, or as shown in Fig. 12 if the sprocket is of the spoked type, the additional width at E Formula (12), being necessary to strengthen the rim and prevent it from cracking while it is being cast.

$$T = 0.9\,S \text{ (see Figs. 13 and 14)} \qquad (9)$$

$$t = 0.6\,T \qquad (10)$$

$$F = d \text{ for roller chain and } 0.75\,d \text{ for all other chains} \qquad (11)$$

$$E = 1.25\,T + \tfrac{1}{8} \text{ inch} \qquad (12)$$

$$G = 0.08\,p \qquad (13)$$

TABLE III. CONSTANTS FOR USE IN DETERMINING SPROCKET DIAMETERS (SEE FIG. 9)

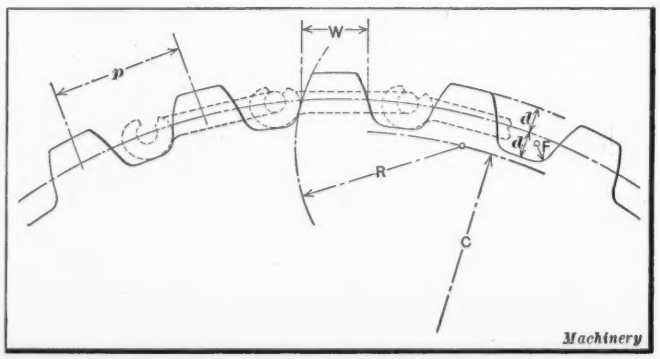
No. of Teeth	Constant k	No. of Teeth	Constant k	No. of Teeth	Constant k
6	1.935	24	7.646	42	13.373
7	2.249	25	7.964	43	13.691
8	2.565	26	8.282	44	14.009
9	2.881	27	8.600	45	14.327
10	3.198	28	8.918	46	14.645
11	3.515	29	9.236	47	14.964
12	3.832	30	9.554	48	15.282
13	4.149	31	9.872	49	15.600
14	4.467	32	10.191	50	15.918
15	4.785	33	10.509	51	16.237
16	5.102	34	10.827	52	16.555
17	5.420	35	11.145	53	16.873
18	5.738	36	11.463	54	17.192
19	6.056	37	11.781	55	17.510
20	6.374	38	12.100	56	17.828
21	6.692	39	12.418	57	18.146
22	7.010	40	12.736	58	18.464
23	7.328	41	13.054	..	.....

Machinery

Note: $m = 0.6p$; $n = 0.4p$.

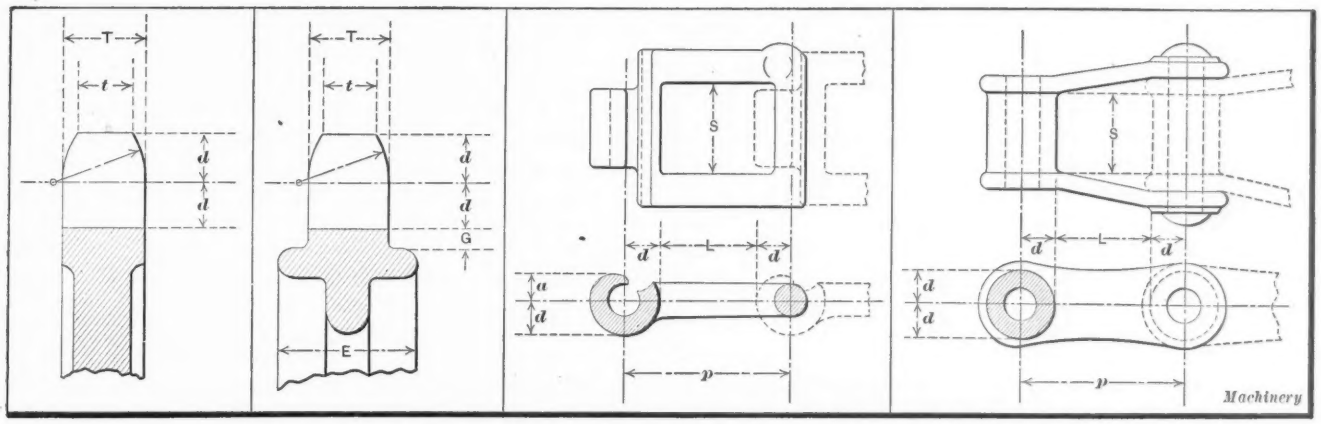
The formulas give a tooth with an angular chain clearance, or so-called "roundness" of 20 degrees, which I have found gives the best results. The smoothness with which the chain enters and leaves the teeth permits of employing a high chain velocity (900 feet per minute for cast chains and 1400 feet per minute for machined chains) and the action is free from jerks. In fact, the factor that limits the speed, as far as smooth running is concerned, is the inaccurate shape of the teeth. The old taper-flank teeth worked very well when a speed of 100 feet per minute was not exceeded, and as higher speeds were required, the experiment of rounding off the flanks was tried.

When the detachable chain makes a reverse bend, the open end of the link rides on the sprocket as shown in Fig. 15. As the addendum a (see Fig. 13) of the chain is less than the dedendum d, it is obvious that the base diameter of such a sprocket must be greater, the pitch diameter, of course, remaining the same. These sprockets are called "traction" or



Machinery

Fig. 10. Diagram showing Method of laying out Sprocket Teeth



Figs. 11 to 14. Diagrams showing the Important Dimensions of Sprockets and Sprocket Chains

"face" sprockets. Face-sprocket teeth are generally run to a point, as shown by the dotted lines in Fig. 15, to distinguish them from the standard sprockets.

There are some chains composed of such long links that the sprocket teeth would be unnecessarily large. Such a condition is shown in Fig. 16. A preferable construction is shown in Fig. 17, where two short teeth are used instead of one long tooth. In this case, if the sprocket has twenty standard teeth, there actually will be forty teeth, and the sprocket is said to be a twenty double-tooth sprocket. Some manufacturers place a web between the double teeth, as shown by the dotted lines in Fig. 17, but I have found it advantageous to omit this. For instance, in long pitch chains, you may

Another type of sprocket is the gap sprocket, shown in Fig. 19; and these gap sprockets are generally used for the reverse chain. When the chain is fitted with attachments for some specific purpose, and a reverse bend is made, the sprocket is provided with a gap or gaps to allow the attachment to pass. Fig. 20 shows one form of these attachments. Of course, where the projections are in the form of side wings, as shown in Fig. 21, the attachment will straddle the sprocket and a gap is not necessary. Cutting out the tooth that interferes with the attachment does not serve the purpose of a gap sprocket, for the attachment and the link will then be too loose, this variation being more and more noticeable as the number of teeth in the sprocket decreases.

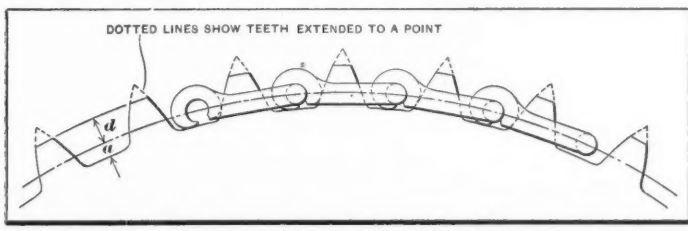


Fig. 15. Action of Detachable Chain in making Reverse Bend

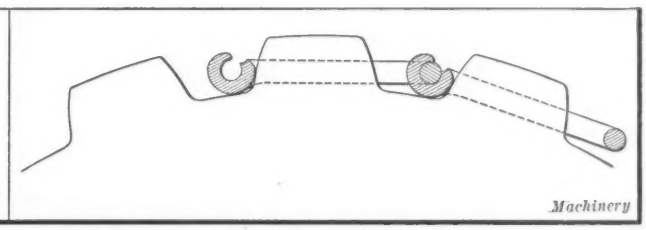


Fig. 16. How Long Links may make Sprocket Teeth too Large

have a tooth ratio of 15 to 21½, and to get whole numbers of teeth this would have to be increased to 30 and 43, where the large diameters would probably be objectionable. Omitting the web permits of using half-tooth ratios, and a sprocket could then have 21½ double teeth. The angle A applies to the pitch of the chain and not to the number of teeth, if there are more teeth than there are links.

For roller chain sprockets, the fillet F is made equal to d, which is the radius of the roller. This gives a smooth action to the chain as the roller bottoms on the sprocket. Fig. 18 shows the form of teeth for a roller chain sprocket. The distance h represents the roller clearance and is equal to 0.05 p. The reason that roller chains may be run at a higher velocity than other chains (except chains of the silent type) is due to the fact that as the roller chain stretches, and the pitch becomes greater, the rotary action of the sprocket throws out the chain and the rollers rise on the flanks of the teeth—automatically adjusting themselves to the larger pitch diameter. Non-roller chains offer too much resistance for this automatic compensation.

The construction of gap sprocket teeth is shown in Fig. 22. The dotted chain links show the incorrect position which would follow if the normal pitch diameter were used. Therefore a new pitch diameter P_G, must be substituted for gap wheels. The value of P_G is found by geometrical construction, bearing in mind that a flat equal to $2p$ is required for each gap, the perimeter of the gap wheel pitch line (including the flat distances) being equal to the normal pitch circle derived from Formulas (1) or (2). The dotted points of the teeth show a preferable construction.

$$\text{Radius } C_G = 0.47\, P_G \qquad (14)$$

Hook-tooth sprockets are used to transmit power from a chain running in a straight or nearly straight line, and they are also sometimes used as idlers for returning a horizontal slack chain if the drive is intermittent and there is a tendency for the chain to jump off an ordinary sprocket. Not infrequently these sprockets have only three teeth. The engaging flank has a 10-degree reverse curve, the construction of which is shown in Fig. 23.

$$P_H = P - 2\,d \qquad (15)$$

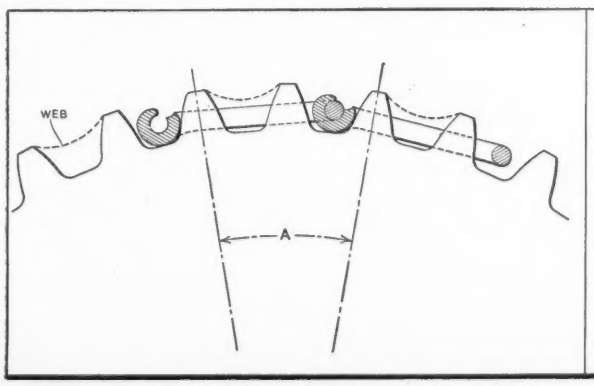


Fig. 17. Two Short Teeth used in Place of One Long Tooth

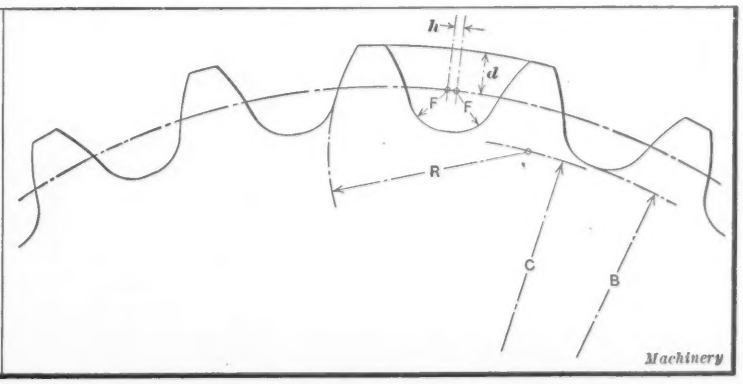


Fig. 18. Form of Teeth used for Roller Chain Sprocket

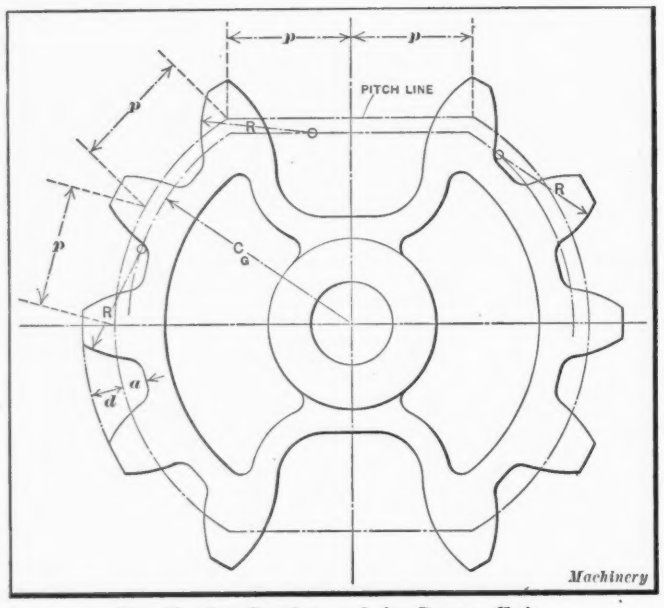


Fig. 19. Gap Sprocket used for Reverse Chain

$$\text{Radius } C_H = 0.47\,P_H \qquad (16)$$

$$\text{Radius } C_A = 0.49\,P \qquad (17)$$

The radius R_H is equal to radius R, Formula (6), except that the minimum radius R_H is found by Formula (18) instead of Formula (17):

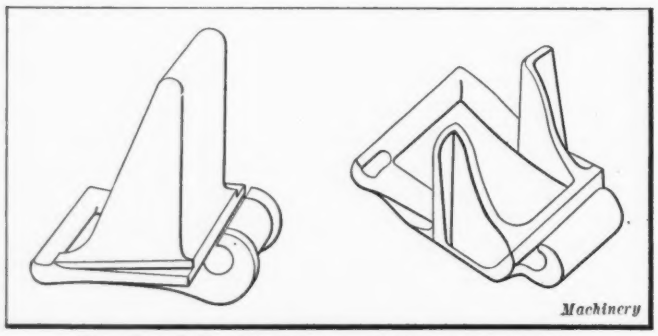
$$\text{Radius } R_H \text{ (minimum)} = p + d.$$

The tooth flanks are rounded at the ends to prevent interference as the chain enters and leaves the sprocket, as shown at X in Fig. 23. Hook-tooth sprockets cannot be used as drivers, as the wear is very great, due to one tooth doing all the driving; and, as the load is transferred from one tooth to another, there is a distinct jerk, due to the link slippage caused by the pitch of the sprocket being less than the pitch on the chain. When these sprockets engage the reverse side of the chain, no corrections are necessary, as in Fig. 15, because the corrected pitch diameter P_H already is smaller than the normal pitch diameter D.

* * *

ALLOY OF NICKEL AND TANTALUM

The resistance of nickel to acids is considerably increased by an addition of tantalum. Ordinarily from 5 to 10 per cent may be added, but the resistance increases with an increasing



Figs. 20 and 21. Attachments carried by Sprocket Chains

percentage of tantalum. An alloy of nickel with 30 per cent of tantalum, for example, can be boiled in aqua regia or any other acid without being affected. The alloy is claimed to be tough, easily rolled, capable of being hammered, or drawn into wire. The nickel loses its magnetic quality when alloyed with tantalum. The alloy can be heated in the open air at a high temperature without oxidizing. The method of producing the alloy consists in mixing the two metals in a powdered form, compressing them at high pressure, and bringing to a high heat in a crucible or quartz tube in a vacuum. For general purposes, the alloy is too expensive.

DIFFICULTIES IN MAKING BRASS DIE-CASTINGS

The successful results which have been obtained in making die-castings of white metal have naturally suggested the possible saving which would follow the development of a process for die-casting brass parts, instead of machining them from bar stock or casting them in sand and then finishing by machine work. Several manufacturers have done experimental work along this line and one or two are making relatively simple parts on a commercial basis; but up to the present time it has not been found possible to make brass die-castings on the scale that obtains in making white-metal die-castings.

One well-known manufacturer of die-castings, who has conducted extensive experiments with the view of determining the feasibility of die-casting various brass and bronze mixtures, has reached the conclusion that the idea is impractical. This is not due to the fact that satisfactory brass die-castings cannot be made, but rather that certain operating conditions appear to impose insurmountable difficulties in the way of making the castings at a price which would enable them to compete in the market with parts made by some other method. The chief difficulties which this manufacturer has encountered are as follows: The dies used for making die-castings are necessarily expensive, and in order to distribute the die cost so as to make it possible to sell the castings at a profit it would be necessary to produce not less than 10,000 parts before the dies were worn out. With white metal it is possible to produce up to 50,000 parts in a single set of dies, but with brass the number of castings produced frequently does not exceed 1000. The reason for this great difference in the life of the dies is that the temperature of molten brass is much higher than that of melted white metal and that the coefficient of expansion or contraction of brass is also much greater. The combined effect of high temperature and the strains imposed upon the die by the expansion and contraction stresses naturally results in its rapid deterioration. These conditions make it practically impossible to produce parts in which through holes or under-cuts are required, and where it is necessary to resort to drilling or machining to bring the die-castings to the required form they can be more cheaply made by other methods.

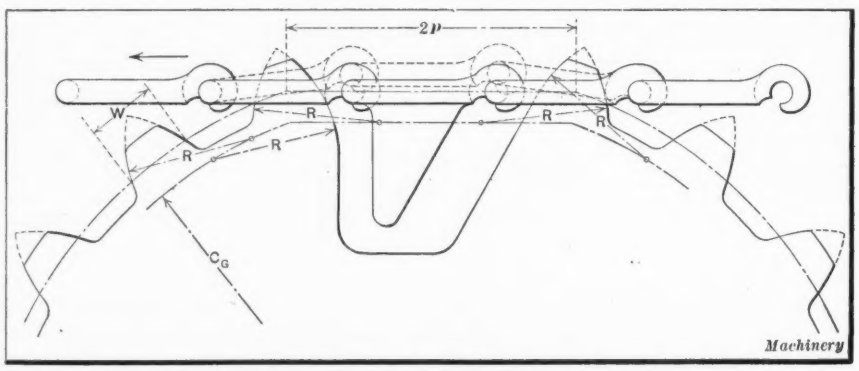


Fig. 22. Typical Layout for Gap Sprocket Teeth, showing Trouble that would follow if a Normal Sprocket Diameter was used

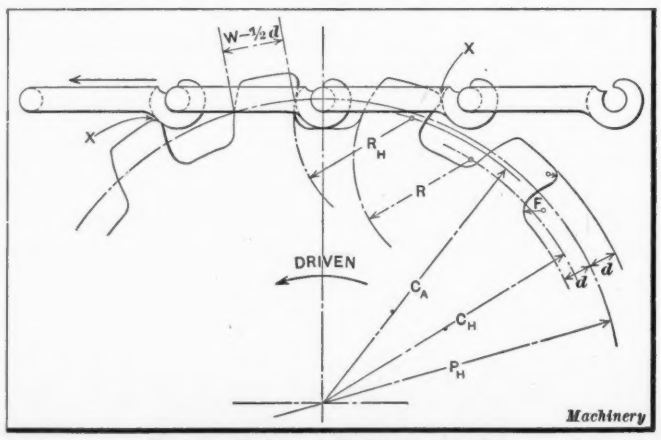


Fig. 23. Design of Hook-tooth Sprocket

The high temperature of molten brass makes it impracticable to use die-casting machines on which the metal is forced into the die by air pressure or by pressure supplied by a hand-operated plunger. The reason is that in such machines the molten metal is held in an iron pot, and the high temperature of the melted copper would result in the rapid destruction of the pot and contamination of the copper with iron which would give it undesirable properties. In the making of brass die-castings, the practice followed is to melt the brass in crucibles and then pour it into the dies. As the high cost of the dies makes it impracticable to have a large number, it is evident that the rate of production is slower than would be the case in pouring an entire crucible full of copper into a series of sand molds made by the match-plate method. This slow pouring of the molten metal, together with the high temperature, will result in the formation of a large amount of dross due to oxidization, and although this dross can be reduced in a reverberatory furnace it is not usually possible to recover more than 50 per cent of the copper content. As a result the loss of copper is a factor that must be taken into consideration.

The foregoing outlines difficulties that have practically decided one successful manufacturer of white-metal die-castings against entering into the manufacture of brass parts by the die-casting method. But the great advances which have been made in the scientific control of industrial work have shown numerous examples of seemingly insurmountable difficulties which can be overcome; and it is entirely possible that means may be found for the successful manufacture of brass die-castings. Few things are impossible, but manufacturers of die-castings who contemplate working in brass will do well to take advantage of the experience of the manufacturer referred to in this article, and conduct their experiments along lines which tend to overcome the difficulties referred to. Such a course would seem to be the means of saving expenditure of money on unsuccessful experiments. E. K. H.

[The foregoing review of the state of the art of making brass die-castings was submitted to the American Metal Products Co., Milwaukee, Wis., which is developing the manufacture of bronze die-castings.—EDITOR.]

BRONZE DIE-CASTINGS

BY PETER J. WEBER*

The conclusion of the manufacturer cited in the foregoing article is not wholly borne out by the experience of our company in the production of bronze die-castings. Our company has been successful in producing a limited number of bronze die-castings and has made sufficient progress in this field to warrant entering it on a commercial basis.

Our experience bears out the statement made in the foregoing article in the production of die-castings in brass or copper-zinc alloys. The particular difficulty encountered in working with copper-zinc alloys is the rapid deterioration of the dies, owing to the tendency of zinc to alloy with iron at high temperatures. This difficulty has been avoided by omitting zinc in the composition of the alloys used for die-casting, but even this course is not sufficient to prolong the life of the die. It was soon found that ordinary steels and cast iron do not resist the action of copper base alloys at the high temperatures at which they must be poured. It therefore became necessary to develop a special steel for the dies and cores. The steel which we are using will permit making from two thousand to five thousand castings from a die, depending on the shape and size of the casting, the number of cores, and the construction of the die mold.

Ordinary brass does not possess sufficient strength at high temperature to overcome the shrinkage strains set up in the castings when cooling in the die, and invariably die-castings made from copper-zinc alloys break or crack before they can be removed from the die. This difficulty must be overcome in a commercial die-casting alloy. Provision must also be made for reducing the time of shrinkage to a minimum so as to hold the castings to size. This has been accomplished by the development of a special power-operated die-casting machine which withdraws the cores, opens the die and removes the castings from the die in the shortest possible time and with the least labor involved.

There are many other details which cannot be overlooked in the successful production of bronze die-castings. The design and construction of dies to increase their life, promote ease of repair, reduce to a minimum the labor cost of production and operation are factors which determine the success or failure of each attempt. Many difficulties are encountered by local shrinkage in different parts of the castings of variable sections, and in the proper venting of the die mold so as to allow the rapid displacement of all air in the molds, by the molten metal entering the die. Some of these problems have been so intricate as to make it necessary to alter the design and construction of the die several times before a piece could be successfully produced. It is evident that the solution of these problems requires special application and concentration of thought on each piece, as each type of casting presents problems wholly different from those encountered in pieces of a different type.

It has been the experience of this company that bronze die-castings cannot be produced in competition with pieces which can be completely manufactured in automatic screw machines, whether in brass or steel. The die-casting process is only commercially feasible when difficult or numerous machine operations requiring a number of different settings in machine tools are thereby eliminated.

Copper base alloys which permit of being die-cast, must be of especially fine quality and great strength, and must be capable of maintaining a condition of stable equilibrium at all temperatures. The bronzes developed by this company have special qualities as to strength, elasticity, hardness and resistance to corrosion, and the fact that it is possible to vary these qualities between wide limits by varying the composition of the alloys renders them adaptable to a very wide variety of die-castings and sand-castings. It is necessary to have a large field in which to select pieces for die-castings of bronze because of the many limitations and difficulties which up to the present stage of development of the process have not been overcome. Because of their great strength, the bronzes produced by this company are capable of displacing iron and steel in the production of finished machine parts, such as die-castings, a field from which ordinary brass or bronze die-castings, if they could be made, are restricted. The bronze die-castings thus produced are stronger and more durable than steel castings. Within certain limitations it has been found possible to compete against iron and steel machine parts made from castings or drop-forgings, despite the great difference in the cost of material.

Owing to the many difficulties involved and the great amount of experimental work necessary, it has not been commercially possible for this company to limit its activities to the production of die-castings but it has also been pushing and marketing its bronzes in other forms such as ingots and sand-castings of bearings, bushings and castings where bronzes of special strength, toughness, hardness and resistance to corrosion are required. No reason is known why the difficulties should not be overcome by persistent efforts along the lines indicated. This company has been producing a number of bronze die-castings such as connecting-rods, bearings, valves, turbine blades, gears, cams and numerous other machine parts. Its process has been limited to the production of pieces of comparatively simple shape, weighing not less than one-half ounce nor more than three pounds and having no long small cores. The die-castings thus produced have been within a limit of accuracy of 0.005 inch from finished dimensions.

* * *

DIE-CASTING ALUMINUM ALLOY

An aluminum alloy especially well adapted for casting under pressure in die-casting machines was patented May 5, 1914, by W. H. McAdams and contains the following ingredients: aluminum, 70 parts; zinc, 22 parts; copper, 3 parts; antimony, 5 parts, by weight. It is claimed that the alloy makes castings which are very strong and resilient and which possess a permanent superior luster.

* President, American Metal Products Co., Milwaukee, Wis.

TUNGSTEN—ITS IMPORTANCE IN THE MANUFACTURE OF ALLOY STEEL

BY ROY C. MC KENNA*

In the past year, the enormous demand created for high-speed steel by the acceptance in America of large orders for shrapnel shells and for war munitions, together with the prohibition of the exportation of tungsten ores from the British Colonies, has increased the price of tungsten ore to five times the normal. The greatest use of tungsten is as an alloy of high-speed steel; that is, tool steel to which tungsten and chrome have been added to impart the property of red hardness. In such steel, from 16 to 20 per cent of tungsten is used. Large quantities of tungsten are also used in magnet steel, but probably 90 per cent of all tungsten ore mined is used in the manufacture of high-speed steel.

Tungsten ore is mined in many parts of the world, but its production in the United States is recorded only since 1900. Before that date, the amount mined here was insignificant. There are four kinds of tungsten ore, known as ferberite, wolframite, hubnerite, and scheelite. All these are mined in Arizona, California, Colorado, Idaho, Nevada, New Mexico, South Dakota, Washington, and Alaska. The oldest and best known tungsten mines are located in Spain and Portugal, but the best grade of ore and the best producing mines are found in Boulder County, Colorado. Tungsten ore is also mined in Australia, India, Japan, Siam, Argentina, Brazil and Peru, but although tungsten ore deposits are found in so many sections of the world, there were produced in the year 1912 only 9654 short tons of 60 per cent tungsten trioxide concentrates, or less than 5000 short tons of pure tungsten.

Fig. 1. Ferberite, a Combination of Iron and Tungsten, mined in Boulder County, Colorado

Fig. 2. Wolframite—Iron, Manganese, Tungsten—mined in Spain, Portugal, South America, Burma, Australia

Fig. 3. Scheelite, a Combination of Lime and Tungsten, mined in South America and Japan

Fig. 4. Ferro-tungsten, an Alloy of Iron and Tungsten, used in Manufacture of High-speed Steel

One of the least known and yet one of the most important of our new industries, established through necessity occasioned by the war, is the manufacture of ferro-tungsten. Formerly American users of this product bought their supply from foreign sources, and as ferro-tungsten is almost entirely used in making high-speed steel, it requires little imagination to understand the helpless position of American steel makers when foreign sources of supply are cut off by war. The United States government should recognize the great value of this new industry, which owing to the condition of mining will be greatly hampered when foreign competition is resumed. I believe that congress should provide a measure of protection to the capital already invested so that the tungsten ore producers may continue always to be independent and safe from the menace of foreign control.

* * *

FRENCH AND BELGIAN MARKETS

BY A. P. DAUTUN†

Many manufacturers now working on war orders seem to think that when the fighting is over, Europe, for lack of money, will no longer be able to buy anything from us. This is a greatly misconceived idea. England, being the wealthiest nation in the world, will always have a gold surplus, even after every other nation is exhausted financially; and she will always be able to pay cash. France and Belgium are not quite so fortunate in this respect. These two countries, to which I would like to draw particular attention, have a shortage of gold. To some this may appear serious, but when one considers the unlimited credit that these countries enjoy, their natural resources and, last but not least, the thrift and industry of the inhabitants, they make a highly satisfactory security. The industrial sections of Belgium and northern France are being sadly devastated, and before the war closes the ruin may be even greater. This may lead some to believe that these two countries will not be in position to do much business for a long time, but remember how Galveston and San Francisco were rebuilt—finer, larger and better in every way. The French people are so sure of themselves that they are now making extensive and thorough preparations for enormously increasing their commerce.

We have arrived at a stage where our production exceeds home demand and our surplus must find an outlet. France and Belgium are beginning to get acquainted with American goods, particularly labor-saving and time-saving machinery. These countries are planning to invest heavily in these lines, provided we, in turn, buy their surplus goods—things that we do not make ourselves. In other words, France and Belgium want to do business with us if we meet them half way. If Americans wish to take advantage of this market, they must see to it that our government makes the necessary changes in the tariff that will permit products peculiar to France and Belgium to enter this country without being heavily taxed. Clear, concise and adequate literature will be needed in the French language by American manufacturers who would take advantage of these great potential markets. No amateur translations can be tolerated.

Actual representatives will be more favorably received than mere agents, as the French and Belgians like to deal directly wherever possible. These representatives should know the language. They should study genuine courtesy and forget the glad hand and the loud vest. It will be highly satisfactory to all concerned if our American manufacturers could organize and place their headquarters in one locality. A permanent exhibition managed by an efficient force and conducted on a high business plane has been suggested. Preparations will have to be made to insure prompt, accurate and thoroughly satisfactory deliveries. The importance of these matters regarding packing, crating, shipment and delivery cannot be too strongly emphasized. Another important consideration not to be forgotten is the possible competition of Germany. The year before the war France imported nearly three times as much general machinery from Germany as from the United States. The French and Belgian hatred of everything German will, of course, be to our advantage, but if we cannot make satisfactory terms, one of the best markets in the world will be lost to us.

France and Belgium are to be modernized to the last degree. Many machine tools will be needed; also factory equipment, contractors' supplies, transportation and conveying machinery, plumbing conveniences, electrical equipment and modern mill machinery of all kinds will be wanted in great quantities. Cash registers and office specialties will be in demand; and in fact every conceivable device needed to facilitate business and enable a nation to become highly productive, even though many of its inhabitants have been lost or crippled, will be required.

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† Address: Freehold, N. J.

HOLDING DEVICES FOR TAPERED WORK*

METHODS OF HOLDING EITHER ROUGH OR FINISHED WORK WITH EXTERNAL OR INTERNAL TAPERS

BY ALBERT A. DOWD†

THERE are many instances when it is necessary to hold a piece of tapered work during the various machining operations. Sometimes the work is tapered on the outside, while in other cases the tapered surface is on the interior. The piece may be either in the rough state, and therefore somewhat uneven, or it may have been partially finished in a previous operation. In the case of a rough tapered surface which is to be gripped, it is evident that the inequalities of the surface must be taken into consideration; while in the event of the surface having been finished, care must be taken to obtain accurate location and provision for driving. The work may be very small or it may be of large size, and the material may be either a casting or a forging, while the tapered surfaces may be at an acute angle with the center line or somewhat obtuse. There may be instances which will permit the addition of holding lugs or their equivalent, while other cases may be susceptible to chucking by means of special jaws.

All of these points have an effect on the method of holding and must be considered when designing holding devices, while the type of machine on which the work is to be done is also an important factor. There is nothing much easier to hold than a small bushing having a shallow internal tapered surface which has been previously machined, and there is nothing much more difficult (under certain conditions) than a large shell of thin section having an outside tapered surface with a rather obtuse angle. The greatest care must be exercised in the design of holding devices for tapered work, and a few of the points to be considered are noted herewith. Specific cases will further be cited and attention called to important points during the progress of this article.

Points in Design

1. Size of the work. This is the first point to be considered, for the selection of the machine is somewhat dependent upon it. It is important to start with the size of the work and decide on what machine it is to be handled.

2. Number of pieces to be machined. If the production is large, every effort should be made to design the holding devices in such a way that broken or worn portions can be readily replaced, and convenience and rapidity of operation must be carefully studied. If but a few pieces are to be machined, the fixtures should be designed as cheaply as possible, yet with the idea of producing the work as rapidly as seems to be feasible. It does not necessarily follow that because a fixture is cheaply made, it must be slow and clumsy in operation, for it is often possible to work out the design so that it will be both cheap and capable of rapid manipulation.

3. Method of holding and driving. Both of these points should be carefully considered and as several methods are nearly always possible, it is well to make up rough sketches of the various schemes and then analyze them to see which offers the most advantages.

4. Accuracy required in the finished product. This is an important point and should influence the design to a considerable extent. For instance, it would be absurd to make up a fixture with all kinds of compensating devices and adjustments for keeping it in perfect alignment, when the work to be done on it was a large boiler nozzle or some such part requiring a tolerance not closer than 0.010 to 0.015 inch. On the other hand, a lack of these refinements on an extremely accurate job such as a piece of gun work, would indicate poor judgment on the part of the designer.

5. Rigidity. This must be considered both in regard to the inherent strength of the fixture itself, and also in respect to the overhang from the spindle if the fixture is designed for use on a horizontal type of machine. A lack of rigidity means the possibility of vibration, resulting in chatter, which is absolutely fatal to good workmanship or accuracy.

6. Angularity of tapered surfaces. This point is of great importance because if the angle is rather small and the work is to be held only by the tapered portion, there is a strong probability that it will slip out of its seat if a slight irregularity is encountered during the machining. I have seen an instance of this kind in a piece having a 10-degree included angle, which persisted in slipping out of jaws formed to the same angle. It is difficult to give a hard and fast rule regarding the angle which can be safely held without chance of slipping, for the direction of the cutting action on the work makes a great difference. Speaking generally, a piece of work requiring no facing or back cutting, and having an included angle of not more than 12 degrees, can be safely held in a set of properly formed grooved jaws. It is always better to be on the safe side and provide additional means of holding when there is the least doubt about the matter.

Methods of Holding Tapered Bushings

Undoubtedly the simplest form of tapered work is a bushing having a cylindrical exterior and a conical interior, and the simplest method of holding work of this kind is by means of various adaptations of the lathe mandrel or arbor. The design of the arbor is dependent, to a considerable extent, on the angularity of the tapered surface and the amount of machining required on the exterior of the bushing. Several examples and methods of holding are shown in Fig. 1. The work *D*, shown in the upper portion of the illustration, is a simple steel bushing having a previously machined internal tapered surface *L* which makes rather an acute angle with the center line. The outside of the work and the two ends *H* and *G* are to be machined concentric and square with the tapered portion. The arbor *A* represents the simplest form of holding device which can be devised for work of this kind. It is flattened on both ends at *J* so that a dog can be applied in either place, and it is centered at *K* so that it can be used on the centers of a lathe. In using an arbor of this kind, the outside of the work can be turned without trouble and the end *G* faced. When it comes to the facing of the end *H*, there is a possibility of the work loosening up unless it has been driven pretty firmly onto the arbor. For this reason light feeds should be used at this point.

The work *E* is a bushing of a similar nature to that just mentioned, but the tapered portion is much less acute and the wedging action of the arbor *A* would not be sufficient to hold it in position. In this instance the arbor *B* is flatted for a dog at *S* and centered at each end for the lathe centers. The work is drawn back onto the taper *M* by means of the nut *R* and the U-collar *Q*. In this connection it is well to note that the outside diameter of the nut is smaller than the inside of the bushing, so that as soon as the pressure is removed from the U-collar, it can be slipped out of the way and the work drawn off over the nut without interference. In operation, the outside turning is done first, then the end *O* is faced, and finally the collar is released to permit the facing of the end *P*, the pressure of the cut being sufficient to hold it in position during this operation.

The lower view in Fig. 1 shows a bushing *F* which has an internal tapered surface at a very slight angle with the center line. The angle in this instance is so small that the wedging action on the tapered portion of the arbor would, under ordinary circumstances, make the use of an arbor press necessary in order to remove the work after it had been machined. The two ends of the arbor *C* are flatted at *Z* and centered in the regular manner; and a nut *W* with a U-collar *V* is used to force the piece onto the taper *N*, as in the preceding instance. After the outside turning and the facing of the two ends *U* and *T* has been done, the knurled collar *X*

* For articles on work-holding devices previously published in MACHINERY see "Methods of Holding and Machining Thin Work" in the August, 1914. number and articles there referred to.

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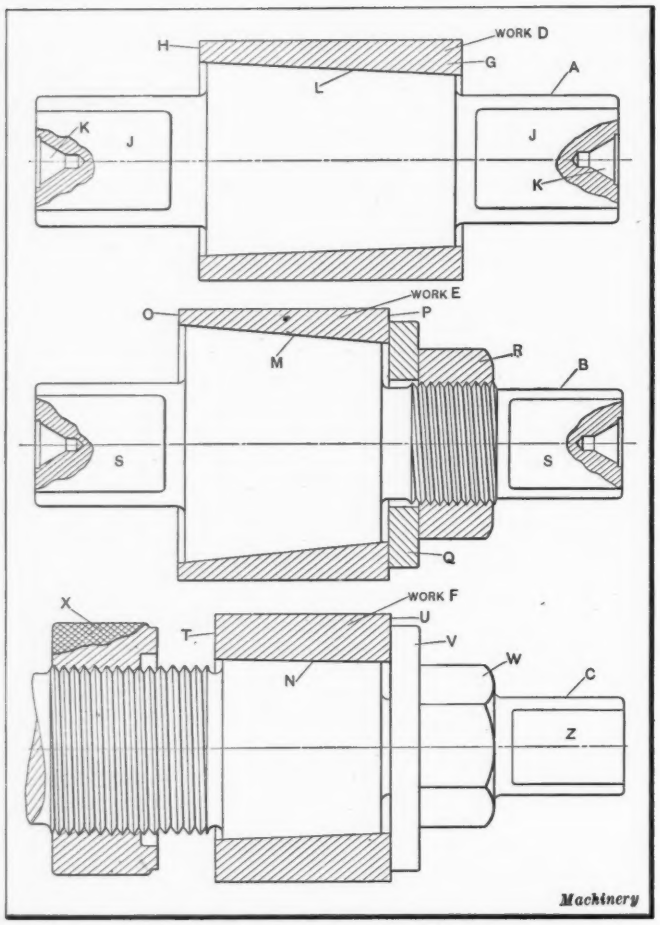


Fig. 1. Methods of holding Work with Cylindrical Outer Surface and Tapered Hole

is spun up against the end *T* to start the work off from the taper. Obviously the U-collar is removed before this is done. An arrangement of this kind makes the use of an arbor press unnecessary, and results in the saving of considerable time.

Holding Device for a Small Tapered Forging

The work shown at *A* in Fig. 2 is an example of a piece which could not be held securely by ordinary methods. The piece was a small steel drop-forging having a tapered portion *B*, the included angle of which was 10 degrees. This tapered part was unfinished and was naturally subject to slight variations. The upper part of the illustration shows

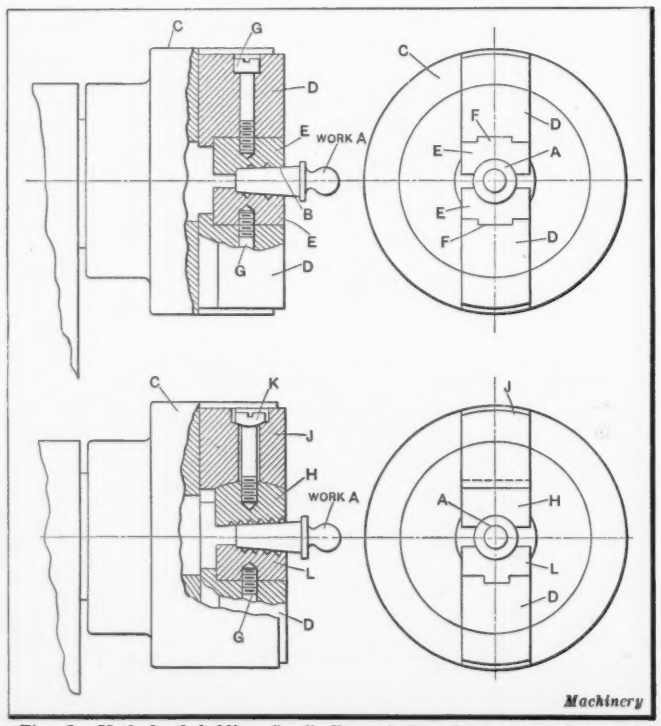


Fig. 2. Method of holding Small Tapered Drop-forging and Improved Method which compensates for Variations in Size

the method by which an attempt was made to hold the work, that was entirely unsuccessful. A two-jawed chuck *C* was equipped with a set of inserted jaws *E* which were formed to the taper *B* of the work, and these jaws were held in position in the main jaws *D* of the chuck, by means of the screws *G*. The jaws *E* were tongued at *F* to fit the main jaws *D*. It was found that any attempt to machine the ball-end portion of the work resulted in a loosening of the hold upon the tapered end so that the work came right out of the jaws, no matter how tightly they were set up.

Occasionally a piece would remain in position long enough to allow the machining to be done, but the greater part of the pieces could not be held. Another method was therefore devised, making use of a swivel jaw in order to compensate for the variations in the rough forgings. The lower part of the illustration shows the construction of the device, the same two-jawed chuck *C* being provided with a set of special jaws, one of which *L* was of the same construction as in the preceding instance, while the other jaw *H* was convexed on one side to fit a corresponding surface in the special chuck-jaw *J*. Provision was made around the screw *K* for a limited amount of "float" so that the jaw *H* could adapt itself automatically to the varying contours of the forging. As the jaws were set up on the work, jaw *H* swung sufficiently to

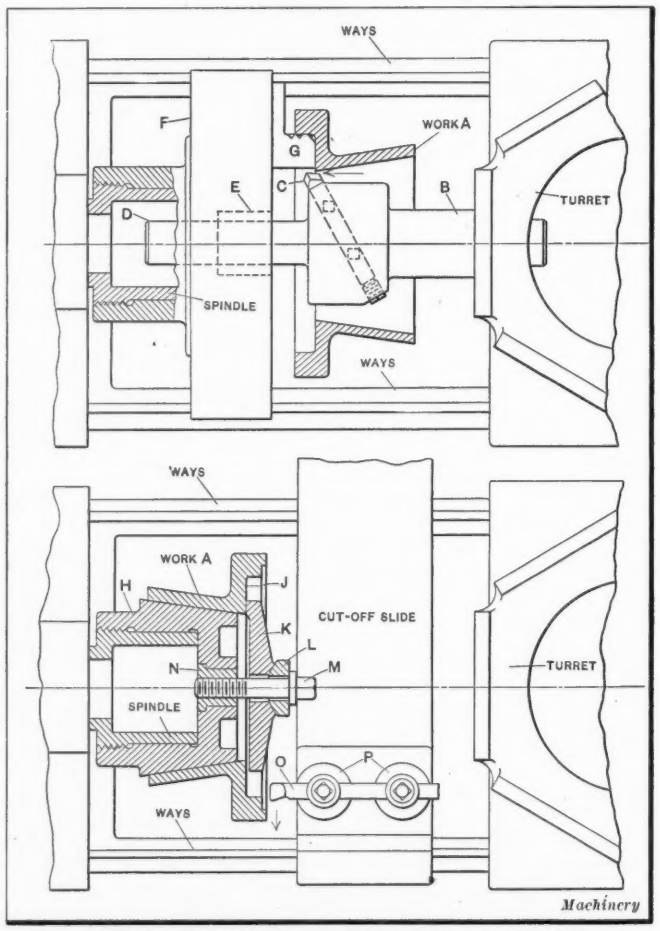


Fig. 3. Work-holding Devices for First and Second Operations on Cast-iron Sleeve

give a good contact, and, therefore, held the piece securely. Had the tapered portion of the work been finished before this operation took place, there is very little doubt that the first method would have given satisfactory results.

Holding Devices for a Tapered Cast-iron Sleeve

The work shown at *A* in the upper part of Fig. 3 is a cast-iron sleeve on which no machining has been done, and which is to be faced on both ends, tapered and recessed as indicated. For the first setting the jaws *G* in the three-jawed chuck *F* are used to grip the work by the inside of the flange, and they are so proportioned that they do not interfere with the action of the boring tool *C* which is piloted at *D* in the bushing *E* in the chuck body. The boring tool *C* is simply used to generate a true running surface for the taper tools which follow it, in order that they may not be influenced by

irregularities in the casting. The shank of the bar *B* is held in the turret hole in the usual manner.

The second setting of the work is shown in the lower portion of the illustration, and the machining to be done during this setting was the facing and recessing of the flange end, to bring it square and concentric with the internal taper. A special steel tapered "nose piece" *H* was screwed onto the end of the spindle to receive the finished part of the work *A*. A steel bushing *N* was set centrally in the face of the nose piece and tapped out to receive the screw *M*. The work was drawn back onto the taper by the clamp *K* which was made to obtain a three-point bearing on the rough surface *J* of the casting, the collar *L* being interposed between the head of the screw and the clamp in order to provide a spherical bearing and neutralize the stresses on both the work and clamp. The facing of the work is done by the tool *O* on the cut-off slide; and attention is called to the method of setting up this tool in two toolposts *P* in order to give rigidity. The sizing of the recess is done by a special tool in the turret. A valuable point in the construction of this device is its compactness and the fact that it is practically built up on the spindle itself, so that there is very little overhang.

External Holding Device for a Tapered Cast-iron Flange

The method shown in Fig. 4 is somewhat out of the ordinary because a piece of this kind would naturally be held by

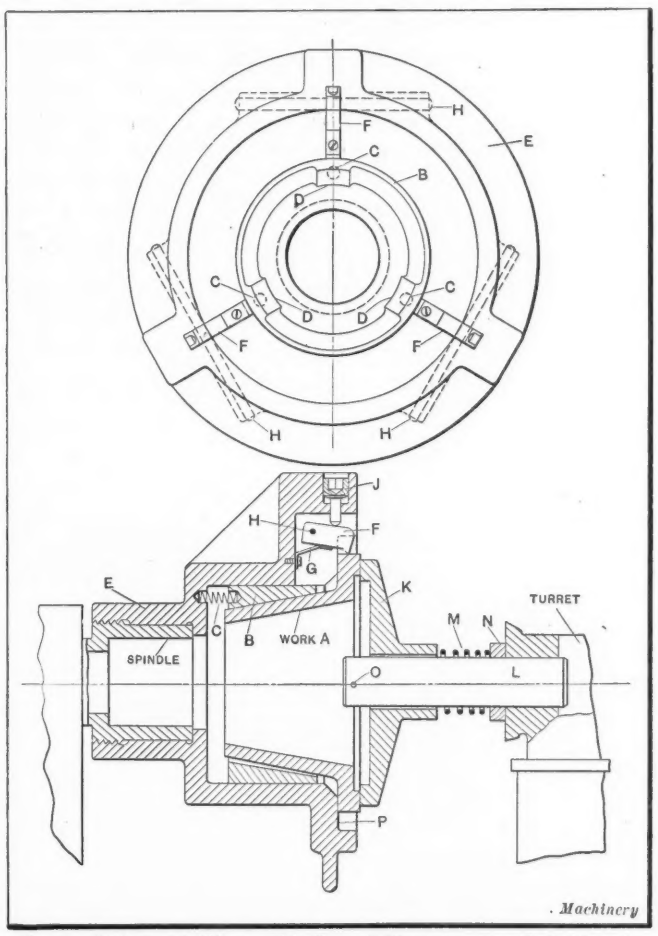


Fig. 4. Method of holding a Thin Tapered Piece so as to afford Adequate Support and prevent Distortion

the outside of the flange in a three-jawed chuck. In this instance, however, the tapered portion being somewhat thin, it was decided that it needed some sort of support in order to lessen the possibility of chatter, so that the chuck-jaw method was deemed unsuitable. The fixture body *E* was made of cast iron and screwed to the end of the spindle. It was provided with a sliding sleeve *B* which was forced outward by three coil springs *C* which were pocketed in both the body and the sliding member of the fixture. In setting up the work, it was placed in the taper bushing and then the turret was brought up until the floating clamp *K* bore against the face of the flange and carried it back against the finished seat *P*. This clamp was a loose fit on the stem *L* which entered the hole in the turret and was provided with a stiff

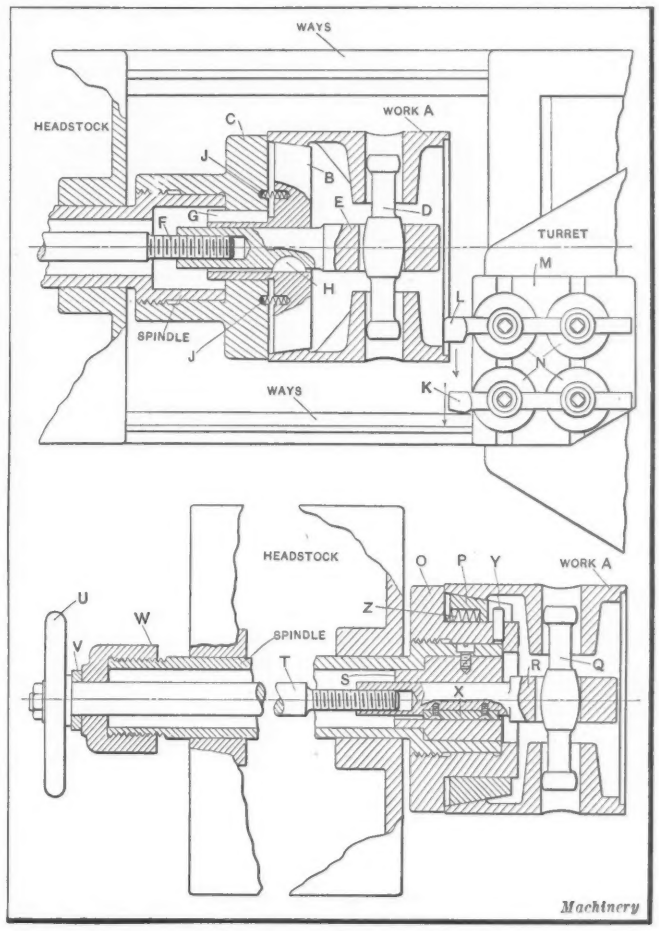


Fig. 5. Fixture for holding Pump Piston, and Later Design which avoids Excessive Overhang from Lathe Spindle

spring *M* thrusting against the back of the clamp and the collar *N* on the stem. The pin *O* prevented the clamp from being forced off the stem by the action of the spring. While

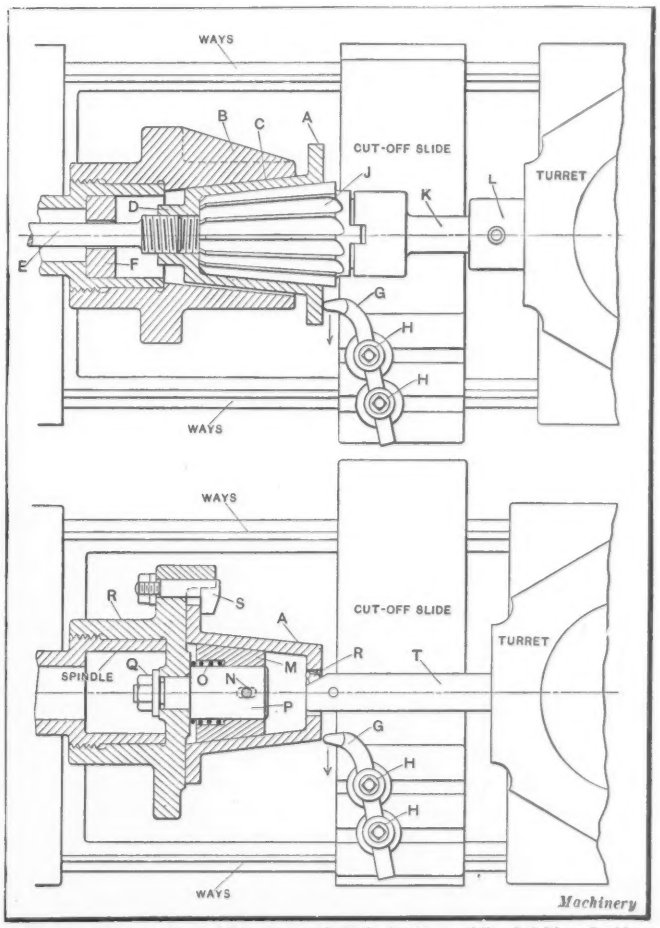


Fig. 6. Fixture for holding Tapered Hub Casting while finishing Inside Surface and facing Ends

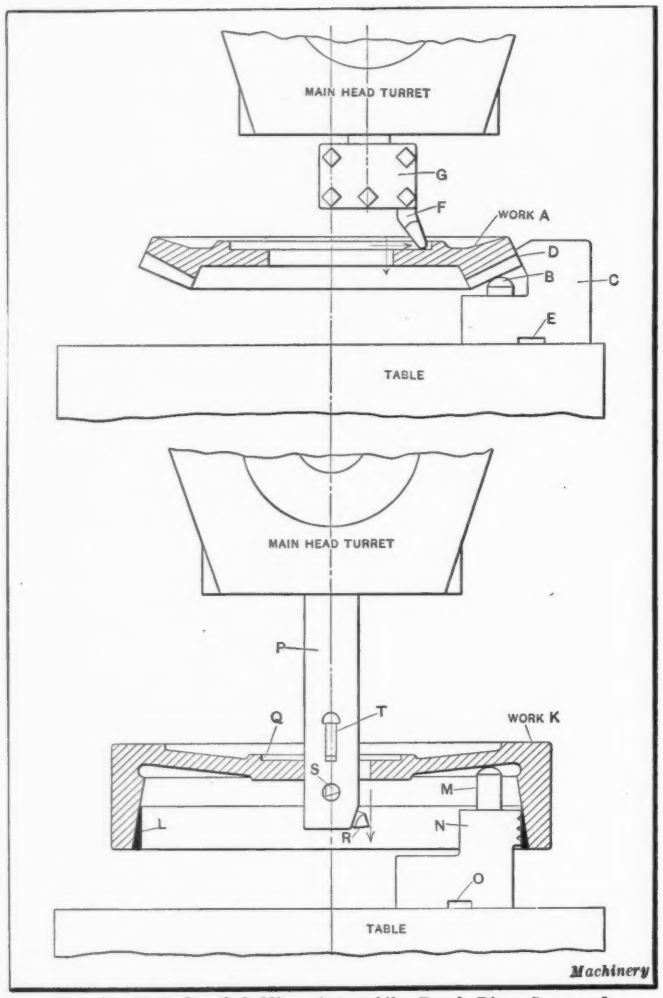


Fig. 7. Methods of holding Automobile Bevel Ring Gear and Automobile Flywheel

the clamp was held firmly against the face of the flange, the swinging dogs *F* were forced into the edge of the casting by the hollow set-screws *J*. Attention is here called to the position of the pins *H*, these being set well back beyond the flange so that as the dogs swing they have a tendency to hold the work back against the surface *P*. The flat springs *G* serve to return the dogs to a normal position. After the work is located in the fixture, the clamp *K* is withdrawn and the turret tools brought into operation.

Two Methods of Holding a Pump Piston Casting

The casting *A* shown in Fig. 5 is part of the piston for a power pump, the tapered portion of which has been machined and the end faced in a previous setting. The upper view shows the original design for the fixture, while the lower view shows a much superior construction which was adopted in place of the original device. In the upper view, the work *A* is located from the previously finished tapered surface, by the spring-actuated floating plug *B* which is a running fit in the body of the casting *C*, the latter being screwed to the spindle. There are four small coil springs *J* let into both the body casting *C* and the plug *B*, and a key *G* prevents the plug from turning. The forged steel link *E* is square at the forward end and bored out transversely to take the pin *D* which enters the wrist-pin hole in the piston. This pin is rounded at all bearing points so that the pressure is distributed, and the casting is drawn back firmly against the finished face of the fixture body casting *C*. The link *E* is prevented from turning in the plug *B* by means of a Woodruff key *H*. The rod *F* is threaded to fit the end of the link *E*, and passes completely through to the rear end of the spindle where it is operated by a handwheel, as illustrated in the lower view. Two tools *L* and *K* are used to face the end of the casting and cut the recess, these tools being held in four toolposts *N* on the tool-holder *M*. The turret lathe used for this work has a turret of the flat variety, with a cross-feed movement, allowing facing and recessing to be done from the turret.

It was thought that the overhang from the spindle was entirely too great in the preceding design, so the one shown in the lower part of Fig. 5 was adopted in its place. It will be noted that in this case the entire fixture is built around the spindle in such a way that excessive overhang is avoided, and a much better design made possible. The body casting *O* of the fixture is screwed to the spindle and the sliding taper sleeve *P* is mounted upon it as far back toward the head as possible. The coil springs *Z* are used to force the sleeve into the tapered part of the work *A*, while the pin *Y* simply prevents too great a movement of the sleeve. A plug *S* is fitted to the inside of the spindle and held in position by the screw. This plug is splined to receive the key *X* in the link *R* which is of similar construction to that previously described. The pin *Q* is the same as that in the upper view; the draw-back rod *T* is threaded with a coarse-pitch left-hand thread at the forward end and serves to draw the pin *Q* back, through the medium of the link *R*, until the end of the work comes against the finished face of the body *O* of the fixture. The collar *W* is threaded to the rear end of the spindle and the rod *T* passes through it and is keyed to the handwheel *U*. The thrust washer *V* is of hardened steel and is interposed between the hub of the handwheel and the collar. It will be noted that although the taper portion of the work is used as the locating point to center it, still the work is drawn back firmly against the squared up end of the fixture so that the longitudinal location is assured.

Fixtures for Holding a Taper Hub Casting

The work shown at *A* in Fig. 6 is a hub casting which is provided with a boss *D* for holding purposes. This boss has been drilled and tapped in a previous operation so that it is approximately concentric with the body of the casting. The fixture body *B* is of cast iron, and is screwed to the spindle in the usual manner. This casting has three shallow internal ribs *C* which are bored to the taper of the outside of the work, the remainder of the inner surface being relieved. The draw-rod *E* is threaded at the forward end to fit the tapped

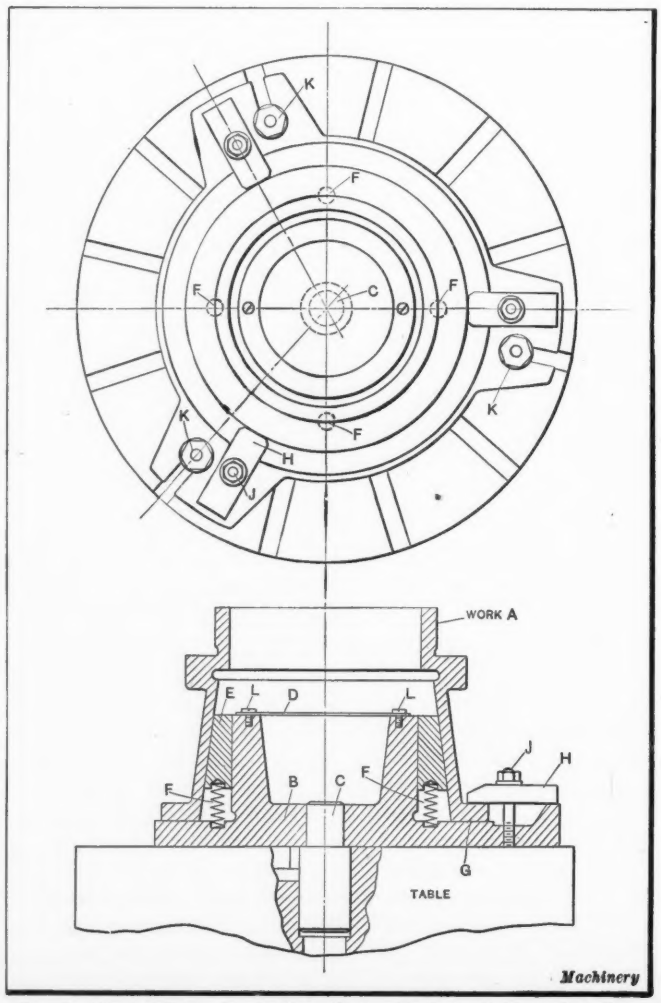


Fig. 8. Simple Fixture for holding Work with Internal Tapered Surface

out portion of the hub on the work, which is drawn back into the fixture by means of a handwheel at the rear end of the spindle, as in the instance previously described. The rod *E* passes through a bushing *F* in the spindle, which serves to hold it approximately central so that it will enter the threaded part of the casting without trouble. There is a clearance of 1/16 inch in the hole to allow for variations in concentricity. A series of stepped tools and reamers are used in the interior work, one of these reamers being shown at *J* mounted on the shank *K* which is hung in the floating holder *L* in the turret. The tool *G* carried in the two tool-holders *H* on the front of the cut-off slide, is used to face the flange while the turret tools are working on the interior, a similar tool at the rear of the slide being used for finish-facing.

The second setting of the work is shown in the view in Fig. 6, the previously machined internal taper and the face of the flange being used as locating points. The body of the fixture *R* is made of cast iron and screwed to the end of the spindle. It is provided with a central plug *P* which is drawn back against the finished pad by the nut and washer at *Q*. On this plug a tapered bushing *M* is mounted, this bushing being of hardened steel, ground to the correct taper and arranged so that it is a nice sliding fit on the plug *P*. The coil spring *O* forces the bushing outward so that it is always in position in the taper of the work, and the pin *N* limits its movement according to the length of the slotted hole. Three hook-bolts *S* are provided in the face of the body casting 120 degrees apart, and these serve to draw the flange back into position against the face of the fixture, thus insuring longitudinal location, while the tapered bushing centers the work. The boring-bar *T* is used to true up the hole and the tool *G* is used for facing. A cutting-off tool on

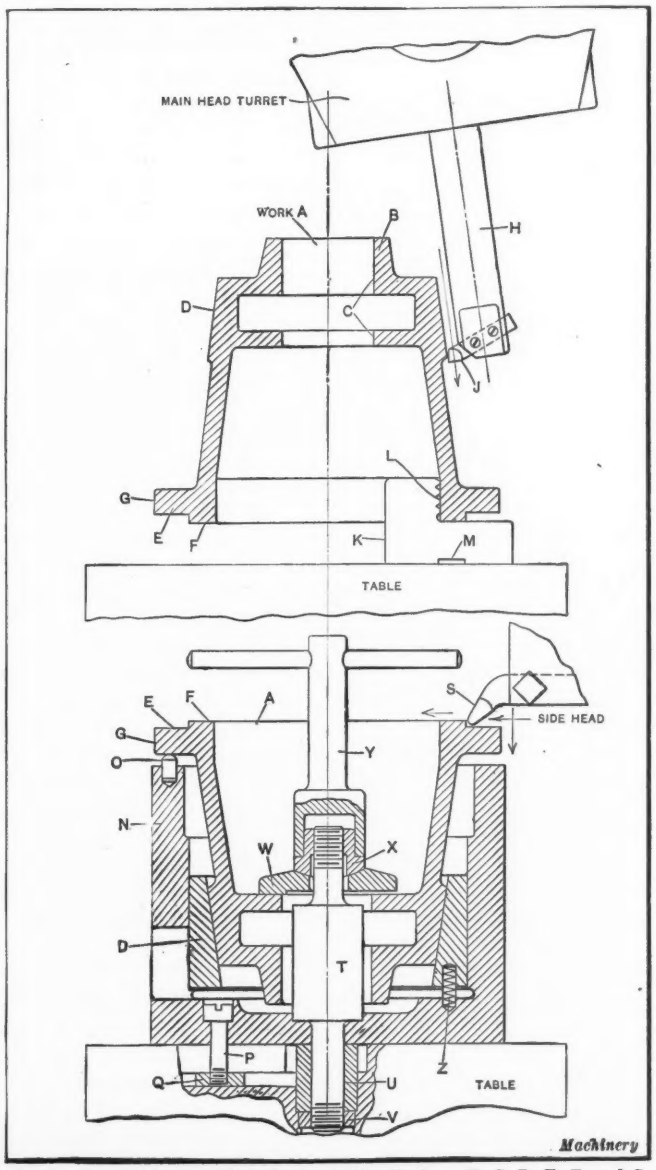


Fig. 9. Two Settings of Work for machining Surfaces B, C, D, E, F, and G

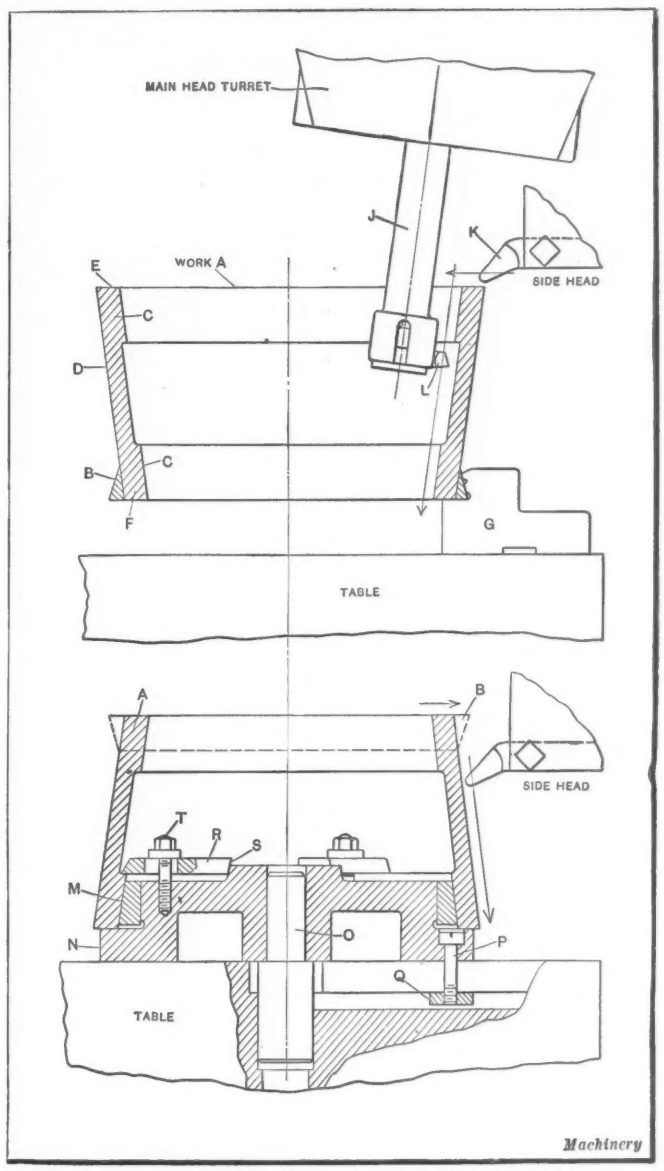


Fig. 10. Another Chucking Application for holding Tapered Work

the rear of the cut-off slide removes the superfluous part of the hub before the facing operation takes place. This tool is not shown in the illustration.

Method of Holding a Bevel Ring Gear

The work *A* shown in the upper part of Fig. 7 is a ring gear for an automobile, the blank being an alloy steel drop-forging on which no machining has been done. A set of special chuck jaws is used to hold the work and the machine used is a Bullard vertical turret lathe. It is well to note that fixtures and holding devices designed for use on this type of machine must be proportionately heavier than those designed for use on the horizontal type of machine, as the machine itself is heavier, more power and heavier tools are used in machining, and the work is generally of a much more massive character. The work is set up on three round pointed raising buttons *B* which rest in the screw holes of the jaws. The jaws *C* are formed at an angle *D* corresponding to that on the outside of the forging, and this angle has a tendency to draw the gear blank down on the pins *B* in the jaws to give an excellent three-point support. The jaws themselves are keyed at *E* to the sub-jaws in the table. The tool *F* is held in a regular tool-holder *G* in the main head turret and is used to bore the hole and face and cut out the recess in the blank.

Method of Holding an Automobile Clutch Flywheel

The work *K* shown in the lower portion of Fig. 7 is a good example of a piece of taper work which would be very difficult to hold unless provision were made in the casting. In this case a chucking ring *L* is added to the casting, thus providing a straight surface which can be readily grasped in the chuck jaws *N*. These jaws are of special design, being cut

away so that the rim of the wheel can be faced or under-cut with this setting of the work. The jaws are keyed to the sub-jaws of the table at *O*. The work is supported, as in the former instance, on the three raising buttons *M* which strike against the web of the wheel. A special three-cutter bar *P* is used to bore and ream the center hole in the wheel. The tools *R* and *S* are used for boring, and the flat cutter *T*, having a floating action which allows it to follow the previously bored hole, does the finishing. The shoulder *Q* is also machined at this setting, and is used for locating the work when machining the other side of the wheel and the clutch taper. A chucking ring may often be applied to a casting to facilitate the holding of tapered work, providing a great number of castings have not been made up previous to the

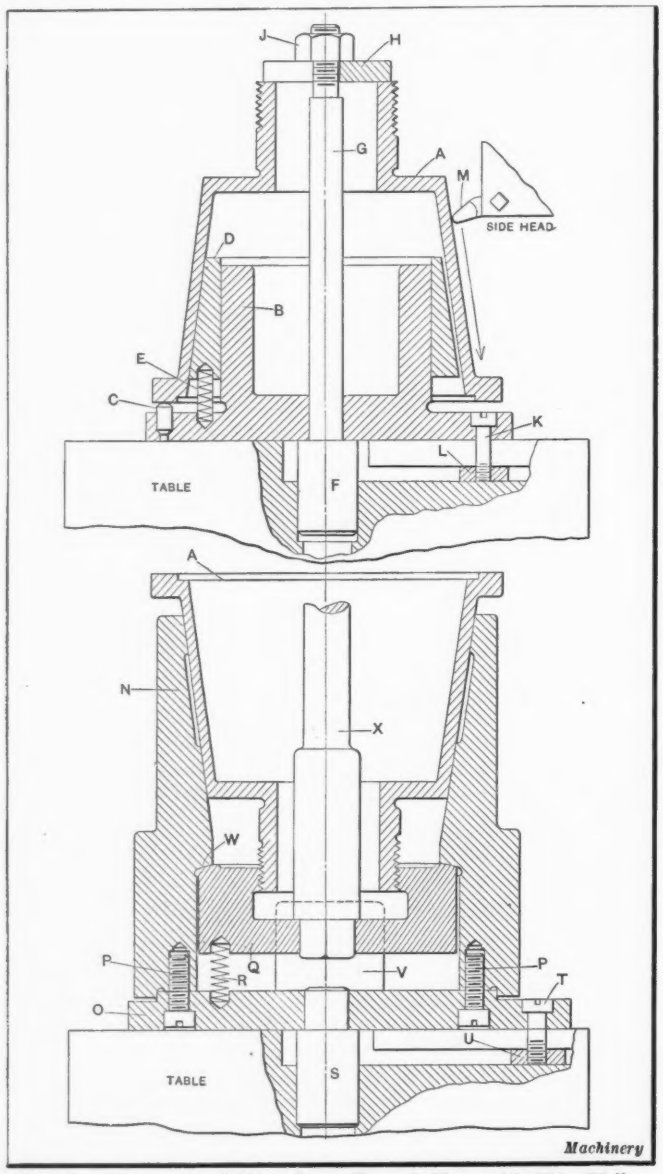


Fig. 11. Fixtures for holding Large Tapered Piece with Thin Walls, which afford Adequate Protection against Distortion

designing of the holding devices. This is an excellent example of the value of forethought in design.

Fixture for Holding a Piece of Electrical Work

The piece shown at *A* in Fig. 8 has been partially machined in a previous setting, but the work remaining to be done must be concentric and square with the tapered portion. The fixture base *B* is made of cast iron and it is centered on the table by means of the stud *C* which enters the central hole in the table. The fixture is held down by means of three T-bolts *K* which enter the slots in the face of the table. These are clearly shown in the upper view. The work locates on the sliding taper sleeve *E* and the flange is clamped down onto the finished pad of the fixture by the three clamps *H*. Attention is called to the fact that the studs *J* are screwed tightly into the base of the fixture and a nut and washer provided at the upper end so that wear of threads cut in cast iron is eliminated. There are four coil springs *F* which are so proportioned that they but little more than hold up the weight of the tapered sleeve, so that when the casting is placed on the fixture the weight is sufficient to bring the flange down on the pad *G*, thereby facilitating the clamping. A sheet steel plate *D* is held in place by the two screws *L* and simply acts as a cover to keep the chips from accumulating in the pocket of the casting. This is an excellent example of a simple fixture for handling work having an internal tapered surface.

Method of Holding a Tapered Electrical Part

The work *A* shown in Fig. 9 is to be machined at *B*, *C*, *D*, *E*, *F*, and *G*, and it is held for the first setting in the jaws *K* by the straight inner surface *L*. These jaws are keyed at *M* in the usual manner. The outer taper *D* is machined by setting over the main head to the correct angle and then turning with the tool *J* held in the bar *H*. The methods of machining the surfaces *B* and *C* in this setting are obvious. In the second setting of the work, the piece is dropped down into the pot casting *N* until the flange strikes the three pins *O* in the upper edge. These pins are equally spaced and serve as a three-point support for the flange. The taper sleeve *D* is supported in the base of the casting by three springs *Z* which are so proportioned as to barely support the weight of the sleeve. The pot casting *N* is centered on the table by means of the bushing *U* on the stud *T*, the latter being clamped down by the nut *V*. The entire fixture is held down on the table by the screws *P* which draw up on shoes *Q* in the table T-slots. The work is clamped by the collar *W* in which the nut *X* has a spherical bearing. The collar *W* is relieved so that it bears on three points on the rough inner casting. A socket wrench *Y* is provided to tighten the clamp. In machining, the tool *S* held in the side head is utilized to cut the recess and face and turn the flange.

Method of Holding a Taper Pot Casting

The pot casting *A* shown in Fig. 10 is another example of a piece of work to which it was necessary to add a chucking ring in order to hold and machine it to the best advantage. In this case the piece was to be machined on the faces *C*, *D*, *E*, and *F*, *i. e.*, all over with the exception of the internal relieved surface which was left in an unfinished state. The chucking ring *B* was cast to an angle of 20 degrees from the perpendicular, and the jaws *G* were made to a corresponding angle so that they drew down on the pot while centering it at the same time. The boring-bar *J*, having a tool *L* at its lower end, was used to machine the inside tapered surface *C*, the head being set to the proper angle; and the tool *K* in the side head faced the end *E* at the same time. In the second setting of the work, the base *N* is centered on the table by means of a plug *O* and is held down by the screws *P* which enter shoes *Q* in the table T-slots. It will be noted that in this fixture there are no projections beyond the casting which is being machined, so that it presents a very clean and neat appearance.

The method of clamping this piece is somewhat out of the ordinary, there being very little surface on which to gain a bearing. The relieved portion on the inside of the casting was only ¼ inch thick. The inner hub on the fixture body casting *N* was machined to a slight angle and the end of the clamp *R* was tapered at *S* to correspond. It will be seen that when the nut at *T* is set up, the tendency of the clamp is to crowd outward into the relieved portion of the casting so that there is no danger of its slipping off the offset. The clamps are slotted in order to permit rapid removal. The ring *M* is a loose piece in this instance, and is slipped into the casting before it is placed on the fixture. In this operation the side head turns the taper, removing the chucking ring *B* at the same time. The taper is generated by means of a side-head forming attachment described in a previous article.

Method of Holding a Thin Taper Casting of Large Size

The work *A* shown in Fig. 11 is of considerable size and its sections are somewhat thin, requiring careful handling in order to avoid distortion. The body *B* of the fixture is

centered on the table by means of the plug *F* which extends up through the body of the fixture and is threaded at its upper portion *G* to receive the nut *J*. A U-washer *H* is thereby brought down onto the top of the hub. The work is located from the internal tapered surface on the sleeve *D* which is ribbed at three points to take care of the inequalities of the casting. There are three springs *E* which support this sleeve. A three-point support for the flange is provided by the hardened steel pins *C* in the base of the fixture. The screws *K* hold the fixture down on the table by means of the shoes *L* in the table T-slots. The tool *M* in the side head is used to generate the outside taper by means of a forming attachment, while the thread is cut on the hub by the thread chasing attachment of the main head.

The method of holding the piece for the second setting is somewhat out of the ordinary, the outside taper being used as a locating point in the internal tapered portion of the fixture casting *N*. This piece is fastened to the base *O* of the fixture by the screws *P*, a shoulder being provided on the former casting in order to make the location positive. The centering stud *S* locates the fixture on the table and the screws *T* hold it down by means of the shoes *U* in the table T-slots. The threaded collar *Q* is supported by three coil springs *R* and has a spherical bearing at *W* in the interior of the fixture. After the work has been dropped down into the pot, the socket wrench *X* is inserted in the square hole of the nut *Q* and the piece drawn down into its taper seat. The spherical bearing at *W* is designed to equalize variations between the thread and the tapered portions. Openings *V* are provided in the outer wall of the fixture so that chips may be readily removed. It will be noted that in both the first and second settings of this piece, the fixtures are so designed that they support the walls of the casting against the pressure of the cut and thereby tend to eliminate distortion and chatter.

* * *

The Electric Power Club, which met at Hot Springs, Va., November 8 to 10, inclusive, has amended its constitution so as to include as members manufacturers of transformers and industrial control apparatus. Five companies manufacturing this class of apparatus were elected to membership, making the membership thirty-four companies in the electrical industry. In the work of standardization of motors and generators, a number of changes in existing commercial ratings were made to bring them within the limits established by the new rules of the American Institute of Electrical Engineers. The allowable variation in voltage at which motors will operate successfully was fixed at 10 per cent above or below the rated voltage. The starting torque for continuous duty polyphase induction motors with full voltage applied was standardized as not less than 150 per cent of full load torque for two-, four- and six-pole motors, 125 per cent for eight-, ten- and twelve-pole motors; and 100 per cent for fourteen-pole motors. The maximum torque for such machines shall not be less than 200 per cent of full load torque. For direct-current motors, the variation of speed from full load cold to full load hot was fixed as not to exceed 10 per cent, based on the full load speed hot. No change was made in the present basis of rating for continuous duty motors and generators used for general purposes, *viz.*, 40 per cent centigrade rise in temperature at full rated load with a 25 per cent overload temperature guaranteed for two hours.

ALIGNING THE PROPELLING SHAFTING OF SHIPS

BY N. I. MOSHER*

In the following article a plan view of the shafting of a twin-screw ship is shown in Fig. 1, which illustrates the crankshafts, thrust bearings, line and propeller shafts. The position of the forward bulkhead is shown at *A* and the after engine room bulkhead at *B*. The spring bearings of the lineshafts, located in the shaft alleys, are indicated at *C* and *D*; *E* shows the inboard bearing of the stern tube; *F* shows the outboard bearing of the stern tubes; and *G* shows the after strut bearings. The bearings *E*, *F* and *G* are in contact with the water and are ordinarily lined with Lignumvitae wood. This article, with the aid of the illustrations, shows a method of establishing shaft centers for the aligning of the propeller and lineshafts of ships. There are a number of methods used in doing this work and any of them will give satisfactory results if carefully carried out.

For the most part the lining up of shafting and machine tools in and about shops is accomplished by the use of piano wire, its use being preferable for this kind of work owing to its high tensile strength which enables it to be drawn very tight without breaking. A test on the Riehle testing machine indicated a breaking strain of 130 pounds on piano wire 0.020 inch in diameter, or 24 gage wire. Fig. 2 shows a small wire winch that is made especially for setting lines; and the construction of this winch is such that the wire can be adjusted while under tension. This device has proved its usefulness many times in shop work, more especially in lining up combined air and circulating pumps, engines, planer beds, shafting, etc.

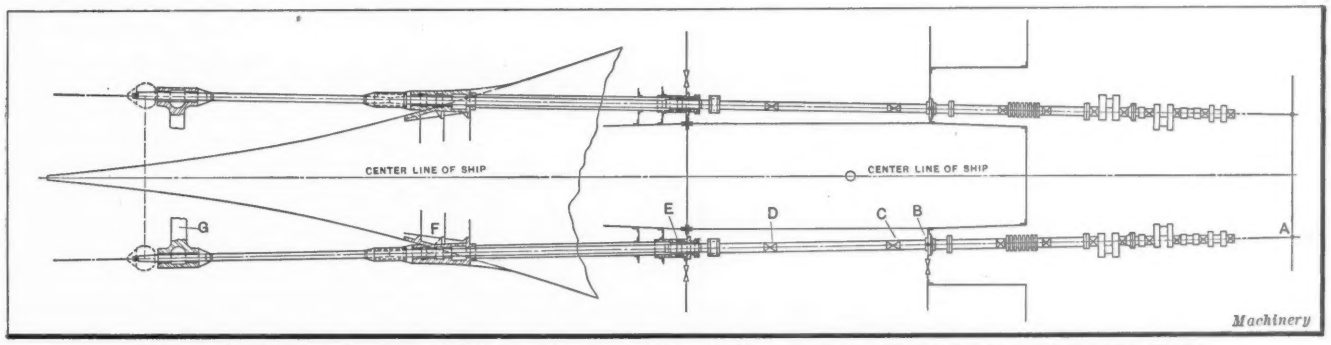


Fig. 1. Plan View of Propelling Shafting of Twin Screw Ship, showing Crankshafts, Thrust Bearings and Propeller Shafts

The writer will endeavor to illustrate and explain two methods that are practiced at the present time in lining up shafting in ships' hulls. In the construction of the hull, the main engine foundation is built to the height and angle laid down in the drawings, and from this foundation the crankshaft centers will be figured. Having determined these centers, a line can be set at the proper distance from the ship's center line. In twin-screw ships the propeller shaft usually runs at a slight angle to the center line of the ship, and these angles must be carefully taken into consideration when setting the crankshaft center line. After setting the line carefully, which line will be secured to the fore-and-aft bulkheads of the engine room, a small hole will be drilled in the fore-and-aft bulkheads, which represents the center of the crankshaft. Around this center will be cut a hole large enough for the installing of the after bulkhead flange, but care must be taken before cutting out the center to scribe a circle on the bulkhead and mark it conspicuously with a center punch, so that the original center can be found if it is necessary.

Having established the shaft center on the engine room bulkheads, the next consideration will be the centering of the after strut bearings. The strut and stern tube castings are usually roughly machined in the shop to within ¼ inch of the finished size. These castings are first set in place and secured to the hull by the ship-fitters, the location to be determined by the plan of the shafting laid down in the ship drawings, as shown in Fig. 1. After having found the

*Address: 15 James St., Winter Hill, Mass.

center of the rough-bored hole in the strut, a parallel strip about 1½ inch square is secured to the end of the strut casting, as shown in Fig. 3, this parallel piece being leveled in a horizontal plane and its top edge set ¼ inch above the actual center of the shaft, so that a center point can be sunk into the parallel to receive the compass point.

Now that the shaft center has been determined in the after strut, a parallel piece of the same dimensions will be secured to the after engine room bulkhead in the same manner as the strut, and over it will be an electric light with a reflector, as shown in Fig. 3. By this method the transit can pick up the parallel edges very accurately, and the work may be performed at night as well as by daylight. After having established the two end centers, as described, the same type of parallel pieces will be secured at as many intermediate points as the occasion demands, assuming one at each end of the stern tube casting, which will also be assumed to be secured the same as the strut, fairly close to the dimensions given on the shaft plan. Having placed as many of the parallel pieces as required, the next operation will be to paint their edges red, white, blue, green or any other striking color that may be on hand; and by setting up the surveyor's transit in a position just aft of the strut bearing, the operator can pick up the extreme aft-and-fore parallels, and the intermediate parallels can be adjusted to line up exactly with them.

The object of the different colors on the parallel strips is to make them more noticeable to the eye of the transit operator. Now that the line on the horizontal plane has been established we turn to the work of the vertical line, which may be accomplished in the following manner: Set the transit to pick up the center line on the after strut and engine room bulkhead parallel pieces, then take a square white card, say 3 by 6 inches in size, and draw a vertical pencil line in the center square with the base. Then place the card on the parallel piece already set in the stern tube, and move the card until the transit operator can pick up the black pencil line. Next carefully scratch a line on the parallel piece to correspond with the pencil line. Continue this operation at each of the parallel pieces and you will have established a line in the vertical plane; and from these points with the square, scratch a line across the face of each of the parallels. Then with the hermaphrodite calipers set at ¼ inch, you will scratch the point ¼ inch below the parallel face, which gives the shaft centers, and from these centers the dividers will scribe a circle for setting up a boring-bar.

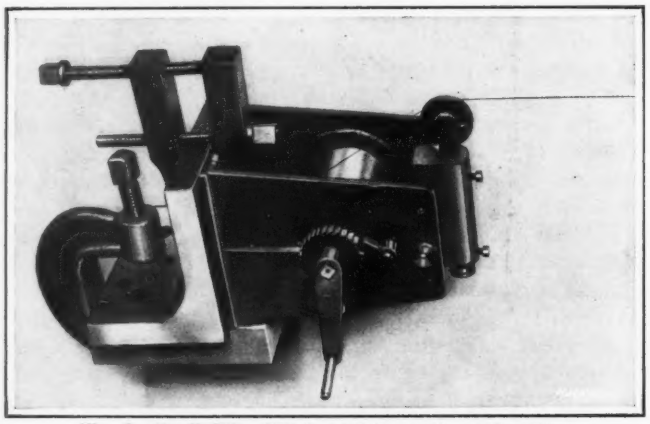


Fig. 2. Small Wire Winch used for setting Wire Lines

After having set the portable boring-bar carefully to the circle, the bar is ready for boring the struts or stern tube, as the case requires.

The aligning of the spring bearing may be taken from a piano wire set up to the center mark in the stern tube and the engine room bulkhead center marks; and the spring bearings, which are finish-bored in the shop, are adjusted to the line. Where it is not practical to use a surveyor's transit, the following method is recommended: Establish shaft centers as above described, and measure the distances between the strut bearing and the engine room bulkhead; then stretch a piano wire between two fixed centers on the floor of the mold loft or the machine shop, which will be spaced equal to the distance between the engine room bulkhead and strut, and attach a weight of, say, 100 pounds to the piano wire, allowing the wire to run over a sheave about 4 inches in diameter or over the wire winch shown in Fig. 2. Set the wire level at each end with the aid of the transit, and on the floor of the shop lay out the points where the bearings and stern tube bearings will come. At these points, use the transit to measure the amount of sag in the line, setting the amounts down carefully for reference when the line is re-set in the ship's hull.

Care must be taken to use the same weight that was applied in determining the sag of line in the shop set-up. The method of establishing the center mark from the wire

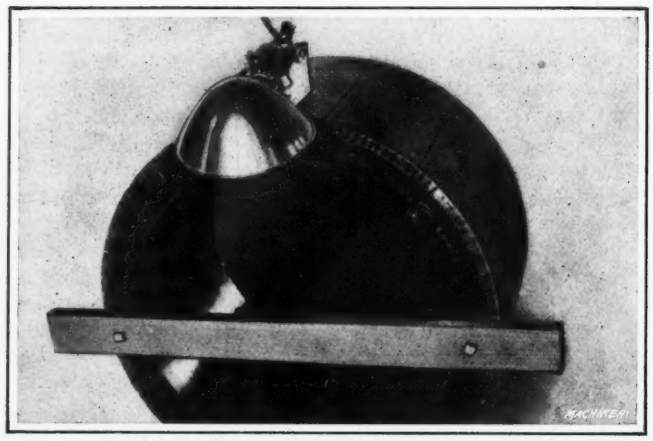


Fig. 3. Rough-bored Hole in Strut with Parallel Strip secured to End of Casting

can be done with the hermaphrodite calipers by setting the radius to the required dimensions and establishing trial centers, just ticking the line from four positions. After actually establishing the center marks, scribe a small circle around each mark so that it may be picked up at a glance. The ordinary portable boring-bar, with a special spider casting for securing the bar to the strut and stern tube castings, can be used for this work. Great care must be exercised in setting up the bar to the center marks already established.

The shafts installed in ships before launching are the propeller shafts and lineshafting that extends through the stern tube bearings. This installation is completed and the stuffing-boxes are packed and glands secured; but it may be advisable to re-align the shafting after the ship is in the water, as it has been found that an alignment may be perfect when the ship is in dry dock and askew when in the water, so that in all cases the alignment should be checked up after the ship has been launched. This can be done by breaking the coupling joints and testing the opening between the faces of the coupling with feelers, as no more positive proof is needed than to know that the faces of the shaft flanges are parallel with each other before bolting them together, since the faces of all shaft couplings are squared up on centers and carefully tested before leaving the machines.

* * *

LUBRICANT FOR THREAD CUTTING

The Geometric Tool Co., New Haven, Conn., publishes a periodical called *Threads*. In the August number the following receipt for the "best lubricant" for general threading is given: 40 gallons of water; 10 gallons of mineral lard oil (of such quality as Union Petroleum Co.'s); 2½ pounds soda ash (no more nor less); and 10 ounces borax. Take a barrel of about fifty gallons' capacity and have it steamed and washed free from all deposits of glue and other residue. Tap the barrel at the bottom for a spigot, and elevate it about eighteen inches from the floor. Weigh the 2½ pounds of soda ash (caustic soda or caustic potash will not do). Thoroughly dissolve this, with the ten ounces of borax, in a bucket of hot water. Place in the mixing barrel. Then fill the barrel about three-quarters full of water, and after agitating this mixture of water and alkali, allow it to stand at least thirty minutes. Then add the ten gallons of mineral lard oil. Upon slight agitation the combination of oil and alkali water will turn white, resembling milk.

ANNUAL MEETING OF THE A. S. M. E.

The thirty-sixth annual meeting of the American Society of Mechanical Engineers was held at the Engineering Societies Bldg., New York City, December 7 to 10, inclusive. A large attendance was registered and many papers of engineering interest were presented and discussed.

President Brashear's address at the opening session Tuesday evening was "Science in Its Relation to Engineering." Dr. Brashear, in a very charming way, showed the interrelation of science and modern engineering and how engineering has been benefited by some of the researches of scientists that to the layman might appear to be of little practical value.

Wednesday morning, following the reports of the committees, a memorial service was held in memory of the late Frederick W. Taylor, past president of the society, notable for his scientific management work. Henry R. Towne presided.

The machine shop session Wednesday afternoon was well attended. The two papers, "Automatic Mechanical Control of Lathes and Screw Machines," by L. D. Burlingame, and "Electric Operation and Automatic Electric Control for Machine Tools," by L. C. Brooks, were of much general interest, as was shown by the lively discussions.

The entertainment features, as usual, were well carried through. Following the president's address Tuesday evening, was the reception of the members and their friends by the newly elected president, Dr. Jacobus, the retiring president, Dr. Brashear, the secretary, Calvin W. Rice, and past-president F. R. Hutton, and ladies. The remainder of the evening was given over to social intercourse and dancing. On Wednesday evening a departure was made from the usual Wednesday evening lecture by holding a smoker. A short vaudeville entertainment was given by some excellent talent. On Thursday evening, the annual reunion, dinner and dance was given at the Hotel Astor. The excursions at this meeting differed from those of previous years in that there were a few of exceptional interest rather than many of ordinary interest.

The following officers were elected for the year: D. S. Jacobus, president; W. B. Jackson, J. Sellers Bancroft, and Julian Kennedy, vice-presidents; John H. Barr, John A. Stevens, H. De B. Parsons, managers; W. H. Wiley, treasurer.

David S. Jacobus, president of the A. S. M. E.

The professional papers presented are given below:

"Design of Fire Tube Boilers and Steam Drums," by F. W. Dean.

"A Novel Method of Handling Boilers to Prevent Corrosion and Scale," by Allen H. Babcock.

"Gas Producers with By-Product Recovery," by A. H. Lymn.

"Modern Electric Elevator and Elevator Problems," by David Lindquist.

"The Application of Engineering Methods to the Problems of the Executive, Director and Trustee," by Hollis Godfrey.

"Turbines vs. Engines in Units of Small Capacities," by J. S. Barstow.

"The Connors Creek Plant of the Detroit Edison Co," by C. F. Hirshfeld.

"Proportioning Chimneys on a Gas Basis," by A. L. Menzin.

"Higher Steam Pressures," by Robert Cramer.

"Heating by Forced Circulation of Hot Water in Textile Mills," by Albert G. Duncan.

"Relative Value of Private and Purchased Electric Power for Textile Mills," by Frank W. Reynolds and Dan Adams.

"The Engineer and the Business of Fire Insurance," by Joseph P. Gray.

"Automatic Mechanical Control of Lathes and Screw Machines," by L. D. Burlingame.

"Electric Operation and Automatic Electric Control for Machine Tools," by L. C. Brooks.

"Report on Safety Code for the Use and Care of Abrasive Wheels."

"Operation of Parallel and Radial Axles of a Locomotive by a Single Set of Cylinders," by Anatole Mallet.

"Four-Wheel Trucks for Passenger Cars," by Roy V. Wright.

"The Heat Insulating Properties of Commercial Steam Pipe Covering," by L. B. McMillan.

"Performance and Design of High Vacuum Surface Condensers," by George H. Gibson.

"Circulation in Horizontal Water Tube Boilers," by Paul A. Bancel.

"Unique Hydraulic Power Plant at the Henry Ford Farms," by Mark A. Replogle.

"The Flow of Air Through Thin-plate Orifices," by Ernest O. Hickstein.

"Elasticity and Strength of Stoneware and Porcelain," by James E. Boyd.

"Foundations," by Charles T. Main.

"Oil Engine Vaporizer Proportions," by Louis Illmer.

"Standardization of Safety Principles," by Carl M. Hansen.

"Modern Movement for Safety from Standpoint of Manufacturer," by Melville W. Mix.

"The Attitude of the Employer toward Accident Prevention and Workmen's Compensation," by W. H. Cameron.

"Industrial Safety and Principles of Management," by W. P. Barba.

* * *

DAVID S. JACOBUS

David Schenk Jacobus, the newly elected president of the American Society of Mechanical Engineers, was born in Ridgefield, N. J. in 1862. He was educated in a private school, then in the Stevens Preparatory School, Hoboken, N. J., where he won by competitive examination a free scholarship in the Stevens Institute of Technology. He graduated with the degree of mechanical engineer from the Institute in 1884 and was appointed associate professor of experimental mechanics, in which capacity he served until 1897 when he was appointed full professor of experimental mechanics and engineering physics, retaining the chair until 1906. From 1900 to 1906, he was also in charge of the Carnegie Laboratory of Engineering, which had been built and equipped for carrying out a course of instruction to supplement class room work by practical experiments made by the students.

Dr. Jacobus developed at Stevens Institute original apparatus for the illustration of physical law and for the testing of various mechanical devices, and he raised the course of experimental mechanics to a high plane by developing a greater degree of participation by the students in practical demonstrations. He is still connected with the Institute as a trustee and special lecturer in experimental engineering. The honorary degree of doctor of engineering from the Institute was conferred upon him in 1906. Since 1906, he has been actively associated with the Babcock & Wilcox Co., maker of water-tube steam boilers, at the head of its engineering department in the position of advisory engineer.

Dr. Jacobus is regarded as one of the foremost American authorities on steam engineering. He has written numerous scientific papers on this subject, many of which have been included in the transactions of engineering societies of this country and published in the engineering periodicals. He was admitted to membership in the American Society of Mechanical Engineers in 1889; he was a manager of the society from 1900 to 1903 and vice-president from 1903 to 1905.

He is a member of American Institute of Mining Engineers, American Institute of Electrical Engineers and the Society of Naval Architects and American Engineers, and a fellow of the American Association for the Advancement of Science. He was president of the American Society of Refrigerating Engineers in 1906-1907. He is a member of the American Mathematical Society, the American Society of Promotion of Education and the Franklin Institute.

GRINDING DIES ON THE BRYANT CHUCKING GRINDER

The grinding machine manufactured by the Bryant Chucking Grinder Co., Springfield, Vt., has been used for several years for internal grinding operations, but recently means have been developed for using this machine for form-grinding dies and similar parts on which it is required to finish a tapered or curved internal surface. In order to explain the method of dealing with work of this kind, we will refer briefly to the way in which the machine operates, so that those readers of MACHINERY who are not thoroughly familiar with the Bryant chucking grinder may understand the efficient manner in which this machine is capable of handling die-grinding operations.

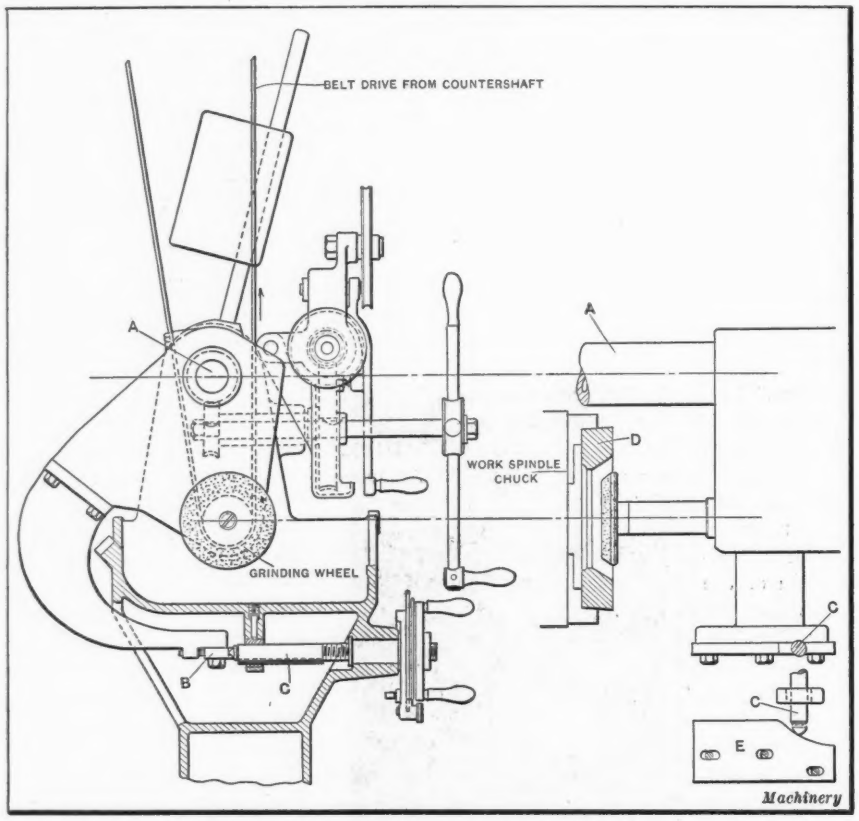


Fig. 1. Bryant Chucking Grinder equipped with Formed Control Plate for the Performance of Die-grinding Operations

Fig. 1 shows a transverse cross-section through the machine and a partial front view. The grinding wheel slide swings about the supporting bar *A*, and a control plate *B* on the slide engages the feed plunger *C* to govern the size of hole to be ground. Screwing in the feed plunger, by means of a handwheel at the front of the machine, results in bringing the grinding wheel into the cutting position ready for operation. The provision which has been made for grinding tapered or curved internal surfaces consists of a formed control plate *B* which is of the same shape as the surface to be ground. In Fig. 1 the partial front view shows the machine set up for grinding a die *D*, and the formed control plate employed for this purpose is illustrated at *E*, with the feed plunger in contact with the plate.

Fig. 2 illustrates a number of different forms of dies which are now being ground on the Bryant chucking grinder. In doing this work, power traverse is employed for the wheel-slide, and the stroke of the slide is adjusted to give the wheel the required longitudinal traverse to move across the entire length of the hole. In grinding straight tapered holes, the grinding wheel is trued to the required taper, and the finishing is done by merely feeding the wheel up to the work. This method has been found to give a very fine finish.

In cases where the surface to be finished is a cylindrical hole followed by a tapered hole, it is often possible to employ a formed wheel with the desired combination of surfaces, and in such cases the action is the same as grinding a simple tapered surface. When the surface to be ground is curved, the wheel is trued to a radius, thus giving a theoretical line contact between the wheel and the work. The range is for dies from ½ inch diameter up to the respective capacities of the machines.

E. K. H.

* * *

An investigation of the fusible safety plugs used in steam boilers has been made by the Bureau of Standards, Washington, D. C., to determine the cause of plugs failing to melt and give warning. Investigation shows that the tin of which the plugs are made becomes oxidized to tin oxide which has a melting point of about 2900 degrees F. This oxidation is due to the presence of zinc in amounts as low as 0.3 per cent. One dangerous condition found is oxidation of the zinc along the grain boundaries, which results in forming a network of oxide throughout the tin. Lead and zinc were found to be the principal impurities in tin plugs, and the conclusion reached was that if these impurities are eliminated by strict specifications and inspection, allowing only the highest grade tin to be used, such as Banca, the dangers will be eliminated.

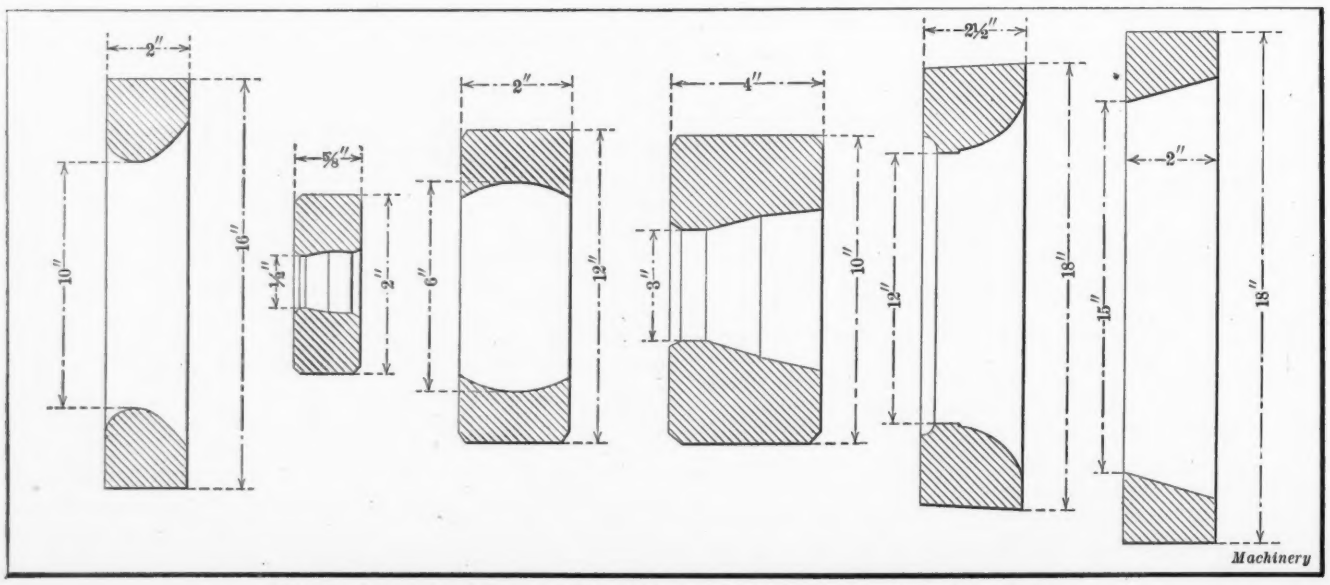


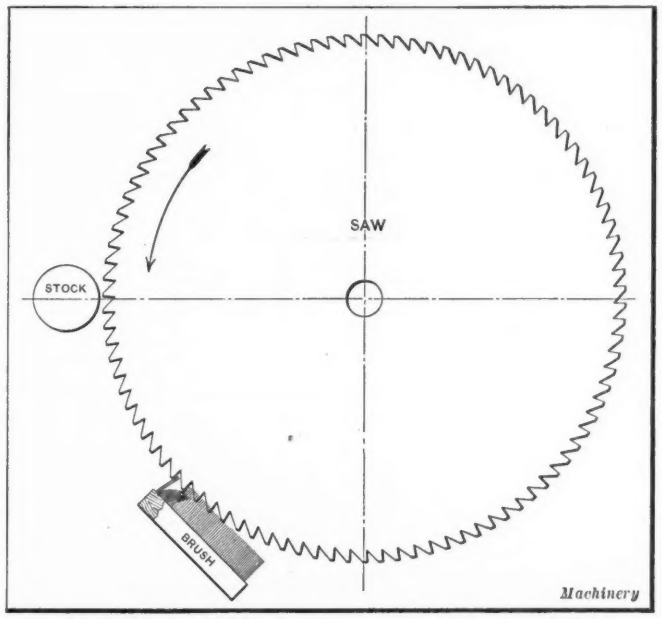
Fig. 2. Cross-sectional Views of Dies which may be finished on Bryant Chucking Grinder

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

BRUSHING CHIPS OUT OF COLD SAWS

In the operation of circular saws for cutting off bar stock in such machines as the Higley, Newton, Espen-Lucas, Cochrane & Bly, Vulcan Engineering Sales Co., and similar types, some difficulty is experienced, particularly when a heavy feed is used, because the chips adhere to the front of the teeth and so prevent them from entering the cut and doing their work effectively. Often a tooth is jerked out of the saw by reason of the fact that the tooth does not do its cutting properly and either the machine, saw or tooth has to break.



Showing Application of Wire Brush for removing Chips from Cold Saws

In trying to overcome this difficulty we have found a very satisfactory remedy.

The remedy consists in attaching to the machine an ordinary foundryman's wire brush in such a position and in such a manner as to brush the chips off the gullets of the teeth just after they leave the cut, thereby taking the chips out while they are hot and before they have time to become sweated on the front of the teeth. In applying the wire brush, it is necessary to rig up a guard to prevent the oil used in lubricating the saw in the cut from splashing on the floor and on the operator. When a very fast feed is used, there is enough heat in the chip itself to affect the cutting edge of the saw.

Another point in the operation of cold saws which may be valuable to MACHINERY's readers is this: Be careful in grinding and sharpening the teeth of these saws that the wheel cuts freely and that it does not blue or even straw-color the points of the teeth. Quite frequently it is the case that a saw on the first grinding will cut quite satisfactorily. But after being ground once the teeth seem softer than before. Heavy grinding and bluing of the teeth in grinding are sure to reduce the temper of the saw at the points where it should be highest, and prevent the saw from doing satisfactory work.

H. C. ATKINS
Indianapolis, Ind. President, E. C. Atkins Co.

DRY BORAX FOR BRAZING

One of the chief difficulties that stands between the amateur brazer and a perfectly brazed joint, is blow-holes. There are many causes for these blow-holes, the two most important being either that the work has been heated to too high a temperature, which causes the brass to boil; or, somewhere, during the process of brazing, water has been introduced.

In the first case, the only precaution that need be taken is to see that the work is never heated above the boiling point of brass. In the second case, water is generally introduced through the medium of the borax, which is used as a flux. As borax absorbs moisture from the atmosphere to a considerable extent, it is always well to keep it air-tight, in glass stoppered bottles, when not in use. As a means of absorbing the moisture that collects while the borax is being used, I find there is nothing better than to suspend a small bag, containing unslacked lime, in one side of the bottle. As unslacked lime is a better absorbent of moisture than borax, the water that is present in the atmosphere will naturally be absorbed by it before it comes in contact with the borax.

As a further means of securing good brazing, brass filings, commonly known as spelter, should, under no condition, be used. As a substitute, brass rods, about 3/32 inch in diameter and two feet long, are very convenient, and will give far superior results. In brazing with brass rods, before applying any flux the work should first be brought slowly to a bright red heat. This operation drives off all surface moisture and grease that may have collected. While the brass and flux are being applied, the flux should be continually stirred by means of the brass rod. This will eliminate any blow-holes that may, for some unknown reason, have formed in the brass.

Although I have used this method for over four years in brazing diamond dies, I have yet to experience a single case where serious blow-holes have occurred.

East Orange, N. J. GEORGE N. GARRISON

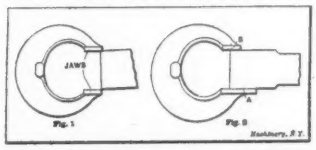
WHAT IS A PATENT WORTH?

Over 1,160,000 patents have been issued by the United States Patent Office, and, while the general feeling seems to be that most of them are of little or no value, there is no doubt that the patent system has tremendously stimulated invention and the development of industries. The following correspondence is reproduced, not to throw discredit on the patent system, but to call attention to the practical impossibility of the examiners finding all references that might be cited against a patent application.

In the December, 1911, number of MACHINERY, Benjamin Brownstein of Ellwood City, Pa., described an improved caliper gage, the feature of which was one extended jaw, the extension being provided for the purpose of guiding the piece to be measured squarely between the jaws.

IMPROVED CALIPER GAGE

Every machinist and toolmaker has undoubtedly experienced some trouble in gaging parallel surfaces with a caliper gage, especially at the moment when the work is about to enter the jaws of the gage. If the gage is held so that the



jaws are slightly inclined to the surfaces to be gaged, the piece will not enter the gage even if it should be several thousandths of an inch under size. This condition is indicated in Fig. 1

In Fig. 2 is shown a caliper gage which eliminates this difficulty and allows the gaging to be done quickly and accurately. When this gage is used, the long jaw *A* is held against one of the sides of the piece to be gaged and moved along it until the piece enters completely between the jaws, provided it is of the correct size or under size. If the piece is above the correct size it will be brought to a stop against the gage as soon as the short jaw *B* is reached.

BENJAMIN BROWNSTEIN

From MACHINERY, December, 1911

1,152,792. INSPECTOR'S GAGE. FRED B. CORRY, Edgewood, Pa. Filed Dec. 2, 1914. Serial No. 875,059. (Cl. 33—148.)

1. A gage having two edges carrying coöperating gage surfaces, one of said edges being continuous or unbroken and projecting beyond the limits of the other to permit of the transverse application of the gage to the object to be measured and to serve as a longitudinal guide.

2. A gage having two edges carrying coöperating gage surfaces, one of said edges carrying non-continuous gage surfaces, the other being continuous or unbroken and projecting beyond the limits of the first to permit of the transverse application of the gage to the object to be measured and to serve as a longitudinal guide.

From Patent Office Gazette, September 7, 1915

A patent was granted to Fred. B. Corry for identically the same idea September 7, 1915, as stated in the following:

Ellwood City, Pa., September 18, 1915.

Commissioner of Patents, Washington, D. C.

Dear Sir:—I have noticed in the Patent Gazette of September 7, 1915, a patent issued to Fred B. Corry, Edgewood, Pa., No. 1,152,792. I must protest against the issuing of the above named patent as it is public property since December, 1911.

In June 13, 1906, I conceived the idea of making a caliper gage with one jaw longer than the other, so as to overcome the inaccuracy of gaging parallel surfaces. I therefore made a sketch of same, which you will find enclosed and marked "Original." Not being able to make much success with the patents I had already taken out, I decided to send it to MACHINERY and have it published as a shop kink, as I had done with other ideas of mine previously. I sent the article "Improved Caliper Gage" to MACHINERY on July 21, 1911, and it was published in December, 1911, of which article you will find enclosed a photo print. Now compare this article, the original sketch and the claims of Fred B. Corry's patent No. 1,152,792.

There is but one conclusion to be derived from this comparison, and that is that this patent represents just what is shown and claimed in my original sketch and article published in MACHINERY, which is already public property, and may be used in many machine shops throughout this country.

Hoping that you will consider this matter in its true light and will let me know your decision as soon as possible, I am,

Yours truly,
Benjamin Brownstein.

Department of the Interior,
United States Patent Office,
Washington, D. C., Sept. 24, 1915.

Mr. Benjamin Brownstein, Ellwood City, Pa.

Sir:—Your letter of the 18th inst. in relation to patent No. 1,152,792 granted September 7, 1915, to Fred B. Corry, has been received. Replying thereto you are informed that a report has been made by the examiner in charge of the case in which it is stated that the publication in MACHINERY in December, 1911, was not available at the time the search was made. In addition, the examiner calls attention to patent No. 199,807.

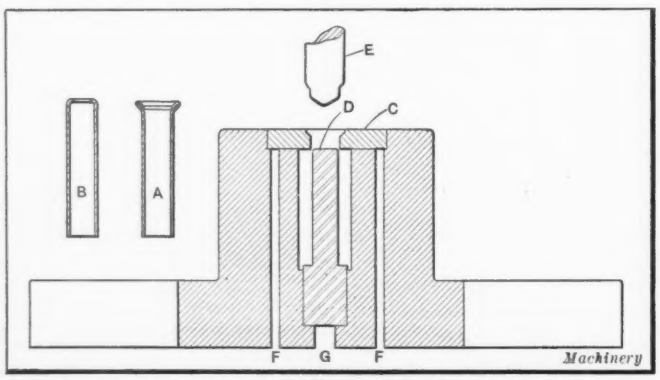
After a patent is granted it passes beyond the jurisdiction of this office.

Respectfully,
W. F. Woolard, Chief Clerk.

A SET OF "FLARING" TOOLS

It was required to produce tubes of the form shown at *A* which have the metal folded in double at one end of the tube and the edge of the tube flared out. The problem of designing the tools for performing the necessary operations gave considerable trouble, but finally we hit upon the idea of drawing up shells of the form shown at *B* and piercing a ¼-inch hole in the bottom of each shell. We then designed a set of tools for use on the punch press, which provided for folding in the edge of the shell and "flaring" out the edge to bring the end of the tube to the required shape. The press tools, which are shown in the accompanying illustration, fold in and flare the end of the tube at a single operation.

The tools for performing these operations on the end of the tube consist of a die-bed, into which is driven the die *C* that forms the outside part of the flared end of the tube. The peg *D* is also driven into the die-bed and is made a sliding fit in the inside of the work. The holes *F* are provided for the



Punch and Die for Use in folding and flaring End of Tube A

purpose of driving out the die *C*, while the hole *G* provides for driving out the peg. In operation, the shell *B* is slipped over the peg *D* and rests on the shoulder at the base of the peg. When the punch *E* descends, the rounded end enters the pierced hole at the bottom of the shell and folds in the stock; after this has been accomplished, the continued downward movement of the punch brings the bevel section into contact with the shell and presses it down into the die *C* which results in flaring out the shell to the required shape. On the up stroke the shell clings to the punch, from which it is readily removed by one hand while the other hand is employed in placing a fresh shell in position in the die. These tools can be used in either a foot press or in a small bench power press.

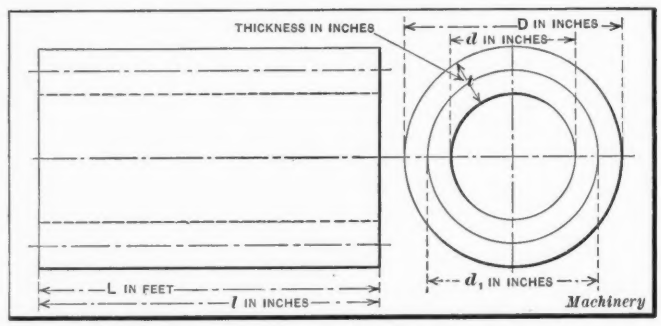
JOHN A. FORBES

WEIGHT OF CAST-IRON HOLLOW CYLINDERS

To determine the approximate weight of a cast-iron hollow cylinder in the foundry, for the purpose of judging the amount of metal needed for casting, the following formula gives satisfactory results:

$$W = 10 d_1 t L$$

in which W = weight of hollow cylinder in pounds;
d_1 = mean diameter in inches;
t = thickness of metal in inches;
L = length of hollow cylinder in feet.



Showing Dimensions of Hollow Cylinders, used in Formulas

In fact, this formula is fairly accurate, as the error is small, the weight obtained being only about 2 per cent greater than that which would be obtained by the use of either of the following formulas:

$$W = 0.2604 \times 12 \times \pi d_1 t L$$

Simplifying,

$$W = 9.82 d_1 t L$$

Another formula is:

$$W = 0.7854 c l (D^2 - d^2)$$

in which W = weight of hollow cylinder in pounds;
D = outside diameter of hollow cylinder in inches;
d = diameter of hole in cylinder in inches;
d_1 = mean diameter of cylinder in inches;
L = length of cylinder in feet;
c = 0.2604 pounds, weight of one cubic inch of cast iron;
l = length of cylinder in inches.

The first-mentioned formula has the advantage of being very simple, and as it gives results which are accurate enough for foundry work it should find a place in every practical man's note-book. The last two formulas give almost identical results and are very accurate.

Another formula for use in figuring the weight of copper tubes or pipes is as follows:

$$W = d_1 t l$$

This gives quite accurate results and is much shorter than the ordinary formula in which the cross-sectional area is multiplied by the length and the constant for copper.

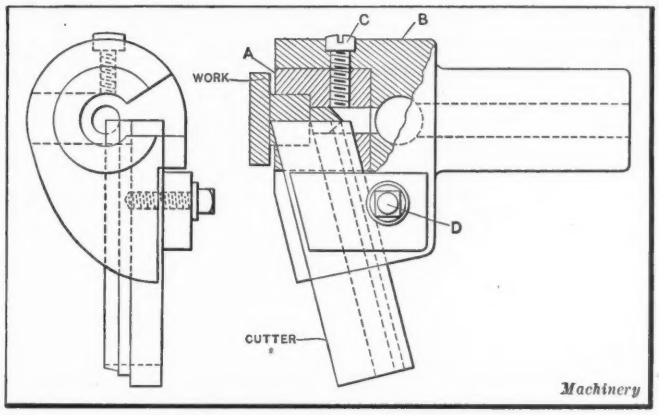
Schenectady, N. Y. W. L. TRYON

A USEFUL BOX-TOOL

The box-tool illustrated and described herewith was made for use in turning brass work, the particular tool shown in the illustration being fitted with a cutter that adapts it for turning work of the form shown. Tools of this type are extensively used in some of the large brass working shops of the Middle West, the features of their design consisting of the ease and rapidity with which they may be set up on a machine, and the provision which is made for working to very close limits. It will of course be evident that such tools can only be used to advantage when there are a large

number of duplicate pieces to be made; otherwise the expense of making such box-tools would not be warranted. It will be evident that the cutter is made of tool steel and is of a form to suit the particular piece of work which is to be turned, due allowance being made for the 15-degree angle at which the cutter is set in the box-tool.

The construction of the tool is, briefly, as follows: A tool steel bushing *A* is bored to fit the work with an allowance of 0.001 inch for clearance; this bushing is hardened to make it durable. The holder *B* is made of cast iron and bored to fit bushing *A* which is held in place by a fillister-head screw *C*. The holder is machined in such a way that there is a solid stop for the cutter to bear against, with the result that the edge is located exactly on the center line. The cutter projects about 1/64 inch beyond the bushing. Where these tools are used it is customary to have a grinding machine equipped with a plate set at an angle of 15 degrees in order to facilitate keeping the angle constant while sharpening the cutters. When it becomes necessary to sharpen the



Box-tool for turning Work of the Form shown

cutter, the operator merely loosens the square-headed cap-screw *D*, slides out the cutter and sends it to the tool-room, where the grinding is done by one of the employes of this department. After it has been sharpened, the cutter is slipped back into the holder until it engages the stop, after which the cap-screw *D* is tightened. When sharpened in this way the cutter will continue to produce work of the required dimensions, no matter how intricate the shape may be.

Rochester, New York. CARL M. WEBER

HANDY KINK FOR DIEMAKERS

One of the best methods that the writer knows of for fitting an irregular shaped punch to a die is described by the following: A lighted wax taper is held close to the face of the punch so that it is covered with a film of black soot. After the entire face of the punch has been covered with soot in this way the punch is struck into the die. It will be found that the soot will not spread—a difficulty which is often experienced when preparations containing oil are used—and that the punch shows a clear white line where it comes into contact with the die. As a result the punch may be machined to an accurate fit.

The same method may be employed in fitting a force to a die used for stamping up irregular shaped brass shells, where it is required to have the force bear all over the inside of the work in order to harden and toughen the metal. The first step is to stamp up the shell after the force has been fairly well fitted to the die by the aid of narrow brass strips of metal that are of the same thickness as the shell. The inside of the shell is next covered with soot from a lighted wax taper in the manner previously described, after which the shell is again placed in the die and given a second blow. When the shell has been removed it will be found that the soot has been deposited on the high spots of the force, which should be machined down to enable it to find an even bearing surface on the entire inside of the shell.

Waterbury, Conn. CHARLES DOESCHER

MEASURING 28-FOOT FLYWHEELS WITH A 3-INCH MICROMETER

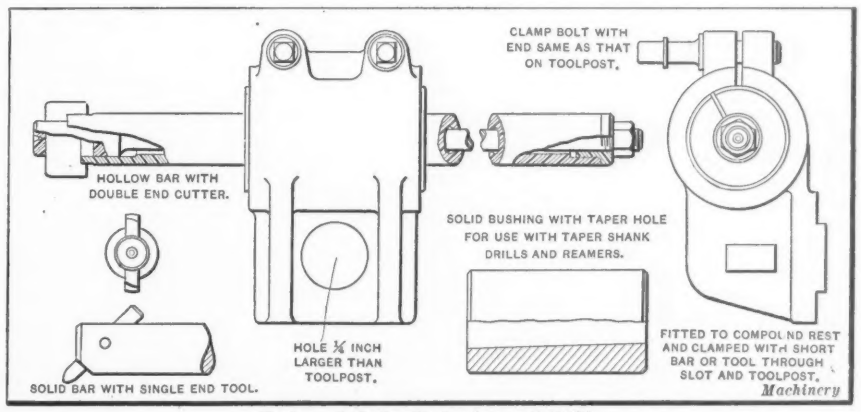
The machinist knows what it is to turn large flywheels and to measure them around the circumference with a tape line. A number of heavy 28-foot flywheels were to be machined on a 28-foot mill. The wheels were split in three sections edgewise, necessitating the machining of each one of a set so that it would be an exact duplicate of the others in the same set. This was easily accomplished by filing off a spot on the inside of the housing opposite the job on the table. Then it was just a case of setting the 3-inch inside calipers to the distance between this spot and the finished rim. This exact distance was found by setting the 3-inch micrometer to the calipers and marking down the size; then the others were made to the same measurement. While the machinist was doing this the boss noticed that the sections were all O. K., and wondered how he did it, as he never saw the machinist measure them. When told how it was done the foreman got busy and had a gage made to fit this space, as the man might turn one or two sections and then quit and no one else would know what the size should be.

Wausaukee, Wis. W. E. BUTLER

COMBINATION LATHE BORING-BAR AND HOLDER

The combination lathe boring-bar and holder shown in the accompanying illustration may be used for boring, counterboring, drilling, reaming, or facing work held in a chuck or on a faceplate or fixture, employing the regular carriage feed of the lathe. The holder consists of a casting planed to fit the compound rest and clamped to it with the regular toolpost and screw, with a small bar projecting through the slot in the casting. This makes the boring-bar holder very easy to attach, the time required to change to either the holder or regular tool being less than thirty seconds. The hole for the bar should be bored with the casting in place on the lathe in order to insure having it in line with the centers. This hole should be about 3 inches in diameter when the tool is made for use on lathes of from 12 to 24 inches swing.

After being bored the casting is split and screws are provided with square ends of the same size as the toolpost screw in order to avoid the necessity for extra wrenches. For use with taper shank drills and reamers, a solid bushing is provided with a taper hole the same as that in the tailstock. For use with the boring-bar or other tool, split bushings are provided for any size of bar that is required; and these may vary from the smallest up to 3 inches in diameter. For general use, a 5/8-inch, 1-inch and 1 3/8-inch solid bar with single-end tools, and a 1-inch and 1 3/8-inch hollow bar with double-end tools, will meet most requirements. The solid bars are made from a piece of bar stock turned to size with a tool


CLAMP BOLT WITH END SAME AS THAT ON TOOLPOST.
HOLLOW BAR WITH DOUBLE END CUTTER.
SOLID BUSHING WITH TAPER HOLE FOR USE WITH TAPER SHANK DRILLS AND REAMERS.
HOLE 1/4 INCH LARGER THAN TOOLPOST.
FITTED TO COMPOUND REST AND CLAMPED WITH SHORT BAR OR TOOL THROUGH SLOT AND TOOLPOST.
SOLID BAR WITH SINGLE END TOOL.
Machinery

Design of Lathe Boring-bar and Holder

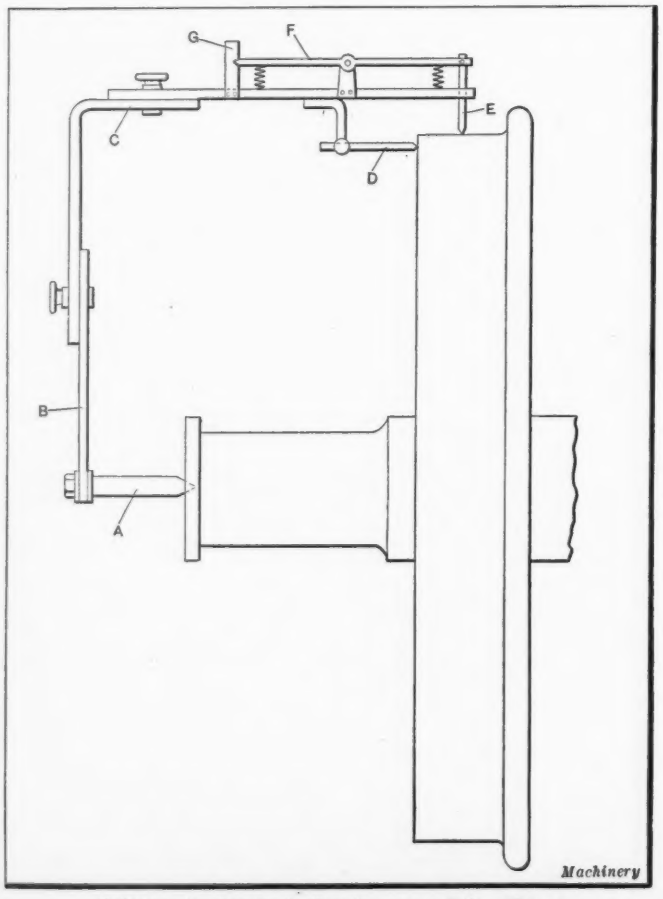
inserted in one end. The bar is made of any suitable length but is allowed to project just far enough beyond the holder to meet the requirements of the work, thus making the most rigid possible construction and still having adjustment to meet the requirements of deeper work.

The hollow bar is made from steel tubing, the tool being held in a slot in the end of the tube by means of a draw-rod. A slot ⅛ inch deep is cut in one edge of the tool to allow of its being locked to prevent endwise movement, the arrangement being clearly shown in the illustration. The tube is also finished for a short distance on each end on the inside, to provide a fit for the draw-rod which is enlarged to fit the tool, and to fit a bushing and washer under the nut. The draw-rod is provided with centers in both ends to permit of its being turned the entire length after the first tool is in place. In this way a very simple and inexpensive method is provided for holding a considerable number of different sized cutters for each size of bar. As all shops have more or less chucking work for which a tool of this kind is adapted, the combination boring-bar will be found to pay for itself in a very short time.

Fairfield, Me. M. P. CHAPLIN

CAR WHEEL INDICATOR

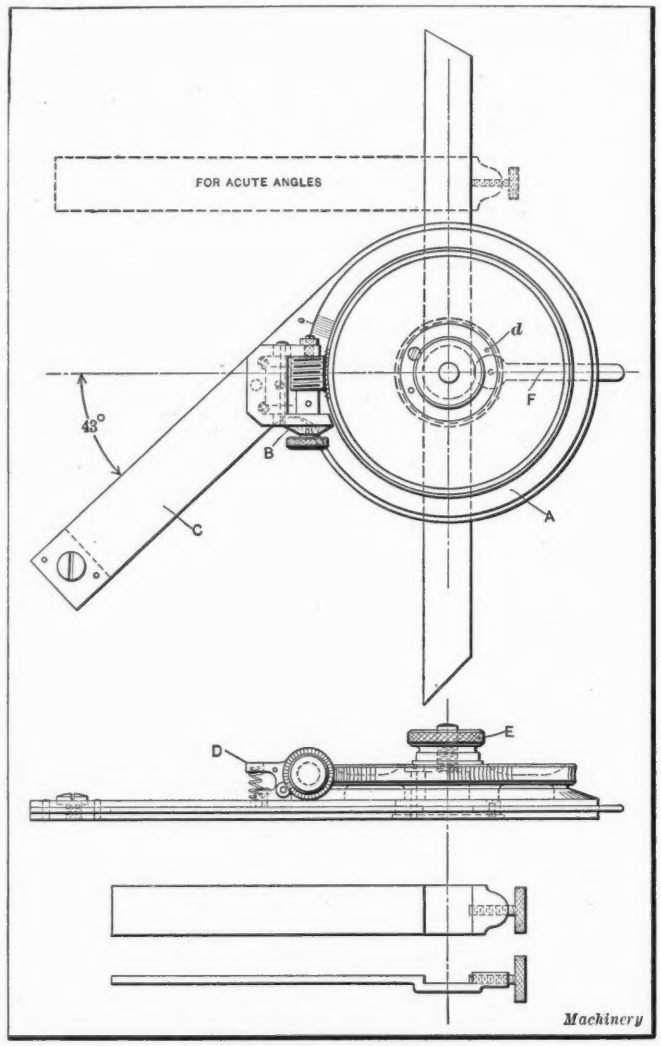
The accompanying illustration shows an indicator for use in determining whether car or tender truck wheels are out of true. A method of determining the accuracy of wheels is highly important, because if they get out of round, heating of the journals and other undesirable conditions are likely to result. Referring to the illustration, it will be seen that the center *A* is placed in the center of the axle, and that this center is supported by an arm *B* which is slotted at the upper end to provide the necessary adjustment for using the indicator on wheels from 33 to 36 inches in diameter. It will also be noticed that means for making horizontal adjustment are provided at *C*, where the connection is slotted for this purpose. The pin *D* engages the side of the wheel and holds the indicator point *E* at the center of the tread of the wheel, the pin *D* having horizontal adjustment for wheels with treads of different widths. The indicating pointer *F* is slotted at the end so that it straddles the scale *G* which is graduated on both sides. In this way, provision is made for reading the indicator from either side. This device has given entire satisfaction in the shops of one of the Eastern railroads, where it has been in use for some time. L. K.



Indicator for Use in testing Accuracy of Car Wheels

PRECISION BEVEL PROTRACTOR

The bevel protractor illustrated herewith will be found useful where exceptionally fine angular measurements are required, as this instrument reads to minutes without the aid



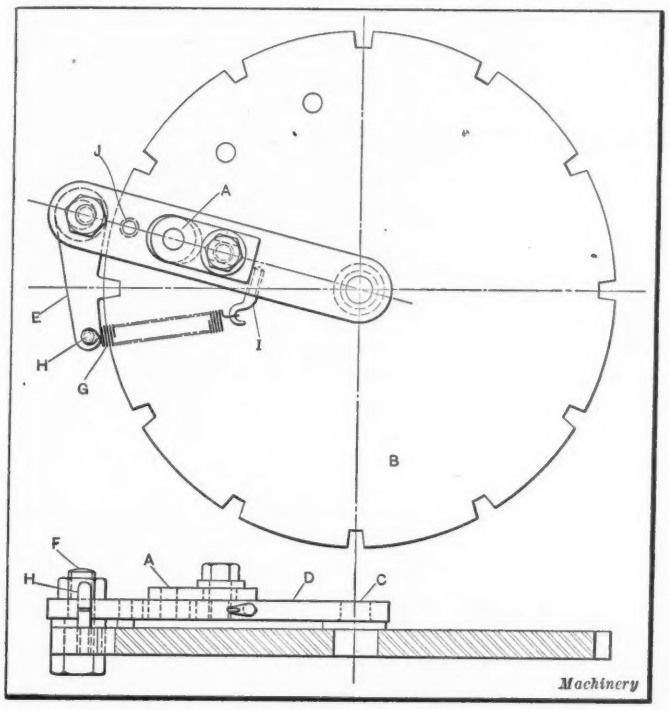
Precision Bevel Protractor

of a magnifying glass. After referring to the illustration, little description will be necessary to make the use of this protractor quite clear. The disk *A* has 360 teeth cut in it and the dial *B* is graduated into sixty spaces. This dial is carried on a short shaft supported in a bracket on the protractor blade *C*. At the opposite end of the shaft from the dial *B* there is a worm which meshes with the teeth cut in the disk *A*. Thus, by turning the dial *B* through one space, the protractor blade *C* moves through an angle of one minute relative to the stock of the protractor. By pressing the end of the small lever *D*, the worm on the end of the dial shaft is disengaged from the teeth in the disk *A*, so that the protractor blade *C* can be swung around to approximately the required position. The worm is then allowed to re-engage the teeth in the disk and the protractor is further adjusted by turning the dial *B*. After the setting has been made, the protractor is locked by tightening the knurled nut *E*. The protractor blade is locked by the binding cam *F*. The instrument is then ready for use.

New Britain, Conn. W. C. BETZ

DRILLING POWER PRESS DIAL PLATES

The accompanying illustration shows a jig used for drilling dial plates of the form employed on automatic feed



Jig for Use in drilling Holes in Power Press Dial Plates

mechanisms for power presses. These were shipped to us by the makers finished all over, with the center hole bored and the notches milled to suit the locating plungers on the power presses, but the holes could not be drilled because the location of these had to be made with reference to the particular presses on which the dials were to be set up. For use in drilling the holes we designed a special jig, but before using it we had to make center punches to fit the punch-blocks on the different power presses and also to fit bushing *A* in the jig. Each dial plate *B* was then put on its bed and the press was set in the usual way, care being taken to have the locking device fit properly in one of the notches. The center punch was then mounted in the punch-block and one prick-punch mark was made on the dial in the proper relation to one of the notches. The dial plate was next placed on the table of a drill press and the center punch was set in the chuck in the drill spindle so that the prick-punch mark on the dial could be lined up with the spindle. The plate was then strapped to the table and stud *C* driven into the center hole. The top of the stud *C* is machined to fit the pivot hole in the arm *D* of the jig.

The next step consisted of lining up the bushing *A* of the fixture with the center punch in the drill spindle. It will be noted that the bushing is made adjustable relative to the center *C* about which the arm swings, so that it may be set in the required position before clamping the binding bolt. The bushing is located in the proper relation to the notches in the dial plate by means of the locking pawl *E*, and the eccentric screw *F* adjusts the position of the pawl relative to the arm *D* of the jig. The pawl is held in the proper notch in the dial by the spring *G* which is mounted on the pins *H* and *I;* and stud *J* is used to hold the arm of the fixture true with the face of the dial plate. It will be evident that after this setting has been made, the bushing *A* is located directly over the center punch mark which was made on the dial plate while the prick-punch was mounted in the punch-block of the power press. The hole can now be drilled in the dial plate, after which successive holes are drilled by simply swinging the dial around the pivot *C* and locking it for drilling each hole by dropping the pawl *E* into successive notches in the dial plate.

Waterbury, Conn. CHARLES E. GRILLEY

INKING OVER ERASURES ON TRACINGS

Recently I had occasion to change the numbers on several tracings, the inking of which had been done on the dull or unglazed side of the cloth. In order to remove all the old ink marks, it was necessary to rub until the fabric of the cloth was exposed. In such cases the ink will not take without running. Having some prepared white shellac on hand, I applied a very thin coating to the cloth. This dried quickly and left an excellent surface on which to do my lettering, there being no tendency for the ink to run.

Cicero, Ill. R. D. BONNAMY

FROM A MECHANIC'S NOTE-BOOK

Always use the right-hand ram for the long reach and the heavy cut on a boring mill. The reason for this is obvious—the strain is too great when pulling away from the rail, which is the condition that obtains when using the left-hand ram.

I have often seen notes on using two blades in a hacksaw to cut slots, etc., but have never seen anything about both of these blades being the same age, which is very important. You want either two new ones or two that have been worn about the same and preferably of the same pitch.

To lay out a keyway on a shaft, especially one with collars, etc., when all finished in the lathe, tighten up the centers and run the tool up to the shaft till it touches. Then run the carriage lengthwise, pulling out the cross-feed to get around the collars, and you will have a keyway laid out with very little work.

It often happens that there is a job to be planed against a shoulder—very often a keyway—and the planer won't stop where you have it set, either riding over too far and breaking off the tool, etc., or not going far enough. The remedy is to tighten up the reverse belt, and you can stop anywhere you want to.

Anyone who has ever had to do much filing on large dies or heavy work of any kind knows what a slow job it usually is. On a large surface, take a ⅝-inch square or a ¾-inch square bastard file instead of one 1¼ or 1½ inch wide, and you will find that you can take off twice as much metal and won't have to push half as hard.

In large shops it is customary to use pin gages to make sizes. On boring mill or planer work when you have a boss or other elevation to face off, in order to get the pin gage squared up under the tool, just take the oil-can and squirt a few drops of oil on the tool; wherever the first drop lands is the exact location for the lower end of the pin gage.

In a small shop it is often necessary to use the vise on the planer to plane up a set of brasses or other small work. Instead of trying to get the vise squared up with a surface gage from the planer bed to the vise jaws, just clamp a straightedge—the longer the better—in the vise. Then you can measure from the edge of the bed to the straightedge with a scale and a two-foot rule and get the vise square at once.

On tool work it is often necessary to make snap gages. The quickest way to do this is to caliper the cutter with a micrometer, and after taking the first cut through the gage use the graduations on the cross-feed, moving the job over the desired amount. After the hardening, they will be warped either too large or too small. Take a light hammer and give the jaws a few blows one way or the other, and many minutes can be saved in grinding and lapping.

On repair work it often happens that you want to make a rod out of cold-rolled stock, just turning down enough on the end to make a fit for the piston and a couple of nuts behind it. Some go to the trouble of getting the steadyrest ready, but that is not necessary. Just prick-punch a good sized center in both ends about where they ought to be. Then use the square center, shoving the back end of a tool that has been ground off smooth against it gently, with a little oil to lubricate, feeding in on the square center until you have a center as large as you want, and the job will run dead true.

Wausaukee, Wis. W. E. BUTLER

* * *

SOLDER FOR ALUMINUM

An aluminum solder patented April 7, 1914, is made up of the following metals in the proportions indicated: aluminum, 17.5 parts; zinc, 52 parts; tin, 30 parts; and nickel 0.5 part. It permits soldering and welding to be done at low temperatures and can be used without acids or welding powders.

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

ALLOWANCE FOR SHRINKAGE IN MALLEABLE CASTINGS

A. S. G.—How much allowance should be made for shrinkage in the making of malleable castings? I understand that malleable castings will shrink more than ¼ inch per foot when cast, and will then expand nearly ⅛ inch when annealed. Is this correct? What means are taken to insure that a casting of the correct size will be obtained after annealing? What will be the difference in gray iron castings and malleable iron castings, cast in molds made from the same patterns?

A.—As the iron used for making malleable castings usually has a shrinkage of practically ¼ inch per foot, with a return of ⅛ inch in the annealing, the shrink-rule of the ordinary pattern shop is used for making the patterns for malleable castings; as a rule there will be no appreciable difference in gray iron castings and malleable iron castings cast in molds made from the same patterns. It should be remembered, however, that the contraction of ¼ inch per foot in malleable castings is not constant, but will vary from 3/16 to 5/16 inch, and, in extreme cases, may even be beyond these limits. This depends on the kind of iron used—the lower the percentage of silicon, the greater will be the contraction. Also, the more sprues used and the more steel used in the mixture, the greater will be the contraction; hence, malleable iron castings made from a pattern used for cast iron should be checked up to make sure that the shrinkage and the return in the annealing are according to the figures given, as otherwise an adjustment must be made in the shrink-rule used. On the whole, the shrinkage of malleable castings is not uniform enough to permit absolute dependence upon the figures given. With rather thin castings, the expansion in annealing may be so great as to counteract the contraction entirely, and the casting will then be as large as the pattern. This is particularly true when the silicon content is high.

PLUG AND RING GAGE ALLOWANCES

F. M. & F. Co.—In the past year we have had several arguments on what size a 4-inch gage should be made in order that it will just fit a 4-inch hole. We looked for an authority on this subject and could find none, there appearing to be no published data or table on allowances for plug and ring gage fits. I would like to see a table giving definite data as, for example, a 1-inch plug 0.0002 inch under size to fit a 1-inch ring; a 2-inch plug, say 0.0003 inch under size to fit a 2-inch ring; and so on.

A.—There appears to be no agreement of gage makers on the matter of allowances for plug and ring fits. One well-known concern claims that it makes the plug and ring of the standard size, *i. e.*, a 1-inch plug measures 1 inch and a ring to fit also measures 1 inch. These can be assembled only by an expert and so close is the fit that the plug must be kept moving constantly or it will be seized by the ring. Other makers of gages make the plug to standard size and fit the ring to the plug, making an allowance of about 0.0001 inch on the 1-inch size. The Johansson gages are made to a uniform limit of 0.00001 inch per inch of length. This is proportional in all sizes, the one-tenth inch gage being accurate to the 0.000001 inch or one one-millionth inch. Having this in mind, the following experiment indicates how small the clearance may be in an accurately fitted plug and ring gage: Four Johansson gages were taken, two half-inch and two of other sizes; the other gages were locked to the half-inch, one on each side overlapping so as to form a snap gage. The three were held together alone by the air suction or molecular attraction that these gages possess for one another. The other half-inch gage or block was forced through the snap gage opening without breaking the air suction between the three assembled gages. Here we have the condition of the snap gage opening being exactly the same size as the gage fitting it, and still the one can be moved freely within the other.

ALLOWABLE TOLERANCES WHEN TESTING ENGINE LATHES

J. J. R.—I am inspecting machine tools for an exporting concern and have to pass on the accuracy of a lot of engine lathes. There seems to be no agreement on the allowable variations in engine lathes, and I would like to have your opinion on the subject.

A.—The limits of various makers of machine tools vary somewhat, it is true, but greater variations than allowed by the makers' inspectors will be found apparently unless great care is taken. When testing an engine lathe, it should be leveled perfectly, and the slides and other working parts should be examined to see that they are free and in good working condition. The carriage should move freely the entire length of the bed, and the cross-slide should also work smoothly and freely. The principal tests for accuracy should be made with a steel bar 12 inches long, provided with a taper shank accurately fitting the taper hole in the spindle. This bar may have, say, three turning points or collars equidistant, from which measurements are taken. With this bar in position, a light chip with a sharp tool is taken over the three collars, and then the collars are measured. All three should measure the same, the allowable variations being 0.0005 inch, plus or minus. The vertical alignment in the 12-inch distance should not vary more than 0.0005 inch up or down. The variation in alignment of the taper hole in the spindle shown by the bar being turned half way around in the hole should not be greater than 0.001 inch at the end. The taper hole in the spindle should run true and there should be no appreciable end motion or shake of the spindle. The faceplate should align with the cross-slide and when faced should be flat, or concaved 0.0005 inch in a diameter of 12 inches. The tailstock spindle when run out full length may have a maximum deviation from truth of 0.0005 inch vertically, preferably upward. The spindle should align with the head spindle in three positions on the bed, the allowable variation being 0.0005 inch upward.

PRACTICE IN SURFACE SCRAPING MACHINE PARTS

R. D. M. Co.—We have had some discussion concerning the correct method of using scraping compound when surface scraping machine parts. Some mechanics contend that the compound should be placed on the surface plate and others that it should be placed on the work. We have heretofore always used the first method but are having very good success with the second. We would be pleased to have your opinion on the subject as to which is the better method. Some contend that placing the marking compound on the work increases the wear on the surface plate. Placing the marking compound on the work has the advantage that it is easier on the men's eyes, as the bright surfaces are covered up and do not reflect the light.

A.—When scraping surfaces of machine parts to a surface plate, the common practice is to apply the venetian red (mixed with lard oil or mineral oil) or prussian blue to the surface plate, and to scrape off the high spots on the work surface as indicated by the red or blue markings. The reverse practice of applying the marking compound to the work is used to some extent by toolmakers, but it has no marked advantage aside from that of reducing the glare of the bright surfaces on the workmen's eyes. On the other hand, the practice has the disadvantage that the scrapings stick to the work and cannot be so easily cleaned off. As far as the wear on the surface plate is concerned, there should be little in favor of either practice. When the marking compound is applied to the surface plate, the plate is somewhat protected by the compound it is true, but as it is not necessary to clean off the plate at each trial when the alternative method is employed, the difference in wear would be very slight. The experiences of readers who have used both methods are solicited for publication.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

AJAX TWO-BLOW HEADER FOR HOT WORK

Until recently heading machines equipped with continuous feed, and intended for working hot metal, have been confined to the single-blow type. Two- and three-blow headers are commonly used for working cold stock, but several difficulties have stood in the way of employing the multiple-blow type of machine on hot material. These difficulties have recently been overcome by the Ajax Mfg. Co. of Cleveland, Ohio, which has introduced a header for working on hot metal in the production of work that cannot be satisfactorily handled by a single-blow machine. A feature of the design is that this header may be converted into the single-blow type, which is an important advantage in adapting it to the requirements of those shops that have not enough work for a two-blow header to keep the machine constantly employed.

A two-blow automatic header for hot work has been developed by the Ajax Mfg. Co., Cleveland, Ohio, in response to the demand for a machine that will automatically upset heads in which the quantity of metal or the shape is such that the work cannot be done in one operation. Screw spikes used by many railroads have such a large head that two upsetting operations are necessary to produce a good job without buckling the material and causing cold shuts in the head. Also hexagon and square bolt heads may be upset on round stock, forming a very good forged bolt head, with a two-blow header, where a single upset can never make a good square or hexagon head from round stock without getting a large flash.

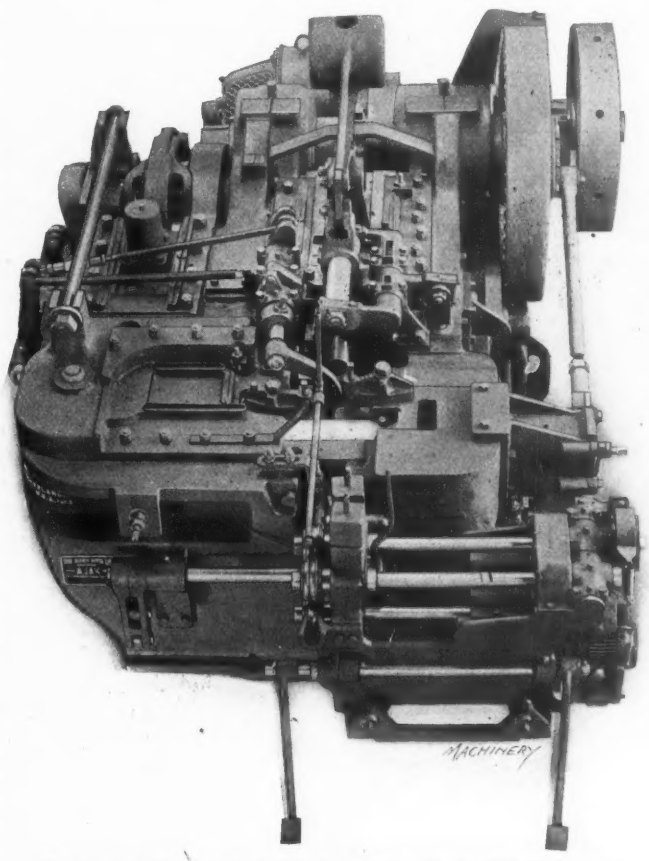


Fig. 1. Top View of Ajax Two-blow Automatic Heading Machine for Hot Work

Until recently, heading machines with continuous feed, for working on hot metal, have been confined to the single-blow type. Two- and three-blow headers for working cold stock are in successful operation, but the problem of adapting the multiple-blow machine for working hot material presents serious difficulties. In the first place, the pieces to be headed hot are generally much larger and require a much sturdier machine to do the work than those which are headed cold. The two-blow machine is necessarily more complicated than the single-blow machine, and where strength and rigidity are of paramount importance, it is necessary for all complications in the design to be kept down to an absolute minimum. Second, the severe conditions under which the dies are worked in the single-blow heading machine are augmented in the two-blow machine. In the single-blow machine the dies grip the stock while it is being headed; then they open and are cooled by running water before they close and grip the stock for another piece. In the two-blow machine the dies open so that the water can get to them only once in two full revolutions of the crank, thus reducing the chance of cooling the dies 50 per cent and increasing the duration of the heating period. The dies must be kept cool to keep them from losing their temper; also the cold water running onto the dies, which have been heated by close contact with the hot stock, is liable to check them. The recently developed special alloy steels which retain their temper to almost a dull red heat have proved invaluable in making dies to be used in both single- and double-blow hot headers.

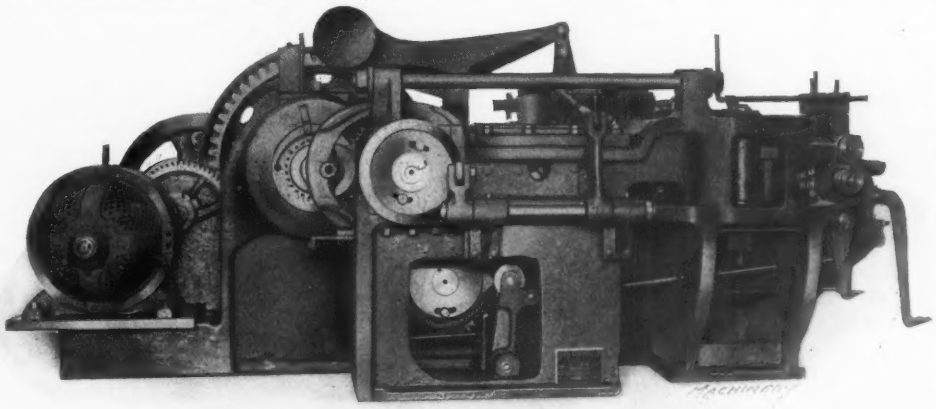


Fig. 2. Left-hand Side of Machine, showing Mechanism for operating Feed Rolls and Stop

The bed plate of the two-blow header is a single steel casting cored out and machined to take the necessary slides, bushings for shafts, and brackets. All moving parts are bushed or lined so that no wear comes directly in the bed casting. The crankshaft bearings are solid, making a much more rigid construction than could be obtained with split bearings; the drive is provided by an electric motor geared to the crankshaft. To prevent damage being done to the motor by stalling the machine, a friction clutch is interposed on the pinion shaft, which slips when the machine stops suddenly. The machine shown in the accompanying illustrations is rated as a 1-inch machine, *i. e.*, it will upset stock up to 1 inch in diameter.

The principle of the two-blow header is fundamentally the same as that of the single-blow machine. It depends on the closing of the moving die to shear the stock for one forging from the bar, and this blank is then gripped between the dies. The heading tools are carried in the main slide which is operated continuously by the crankshaft. These tools receive the material which protrudes from the dies, and form it to the desired shape, the forming operation taking place during the last part of the forward

stroke of the slide. The necessity of holding the stock in the dies, while the tools come forward twice, introduces several difficulties which have to be overcome.

The cam which operates the moving die runs at one-half the speed of the crankshaft, being driven by gears which have a ratio of 2 to 1. This forged-steel cam moves the roller arm which embodies the safety device, and operates the dies through a knuckle system. These features are illustrated in Figs. 1 and 3. The safety device consists of a wedge which is forced between two rollers against the force of two heavy compression springs, if the resistance offered to the closing of the dies becomes too great. It will be noticed that the roller arm is of very heavy construction and is guided rigidly in the bed of the machine.

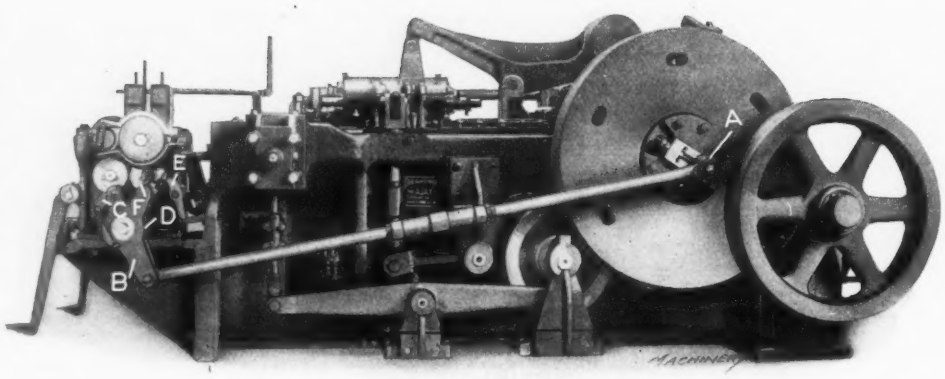


Fig. 3. Showing Mechanism for operating Intermittent Feed Mechanism, Movable Die and Vertical Tool-slide

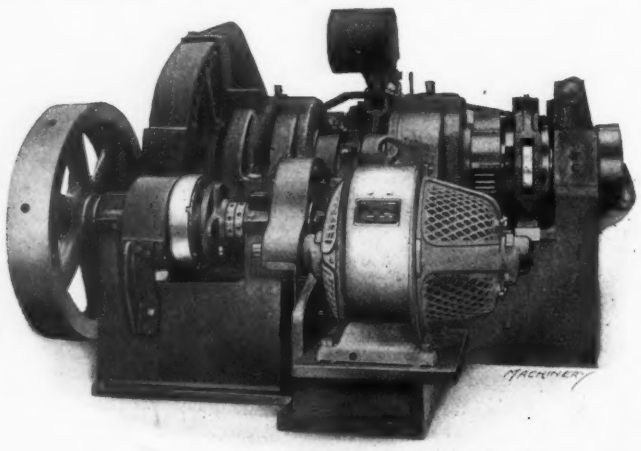


Fig. 4. Back View of Machine showing Arrangement of Drive

The mechanism for moving the tool-holder up and down, so that one tool operates on the material during one forward stroke and the other tool during the following forward stroke, is actuated by a cam on the lower cam-shaft. This shaft is driven by a gear from the die-slide cam-shaft and runs at the same speed. The cam is so designed that the movement of the tool-holder, either up or down, is accomplished during the back half of the stroke, so that when the tool approaches the dies or recedes from them it travels in a horizontal line during one-half of the stroke. This allows the tool-holder to be guided horizontally during the first half of the stroke by a guide bolted rigidly to the bed of the machine, thus insuring perfect alignment when the material is being upset. The motion is transmitted from the cam to the tool-holder through the roller arm, link, and lever. The reciprocating motion of the header-slide is taken care of by the top of the tool-holder sliding back and forward on a large bar in the lifting lever.

The stock gage is operated from a cam mounted on the end of the die-slide cam-shaft, the arrangement being shown in Figs. 1 and 2. The stock gage drops into position as the stock is fed into the machine, then moves out of the way of the first upsetting tool as it comes forward, and remains there until it is needed to gage the stock when it is next fed into the machine. After the forging operation has been completed and the dies have opened enough to release the work, the piece is ejected from the dies by a "kicker" similar to that used on single-blow machines; this kicker is operated from a cam on the end of the lower cam-shaft, as shown in Fig. 2. As the lower cam-shaft runs half as fast as the crankshaft, the design of the kicker cam is very similar to the cam used on the single-blow machine, *i. e.*, it has one high spot that throws the kicker against the finished piece and ejects it from the dies.

The mechanism used to feed the stock into the machine is identical with that used on the single-blow machine, except that an additional device is added to make the machine feed at alternate revolutions of the crankshaft, the mechanism being shown in Fig. 3. The feed rolls are turned during slightly less than 180 degrees rotation of the crank by eccentric *A* on the crankshaft. Arms *B* oscillate pawls *C*, thus rotating ratchet *D*. Pawl *E* rotates a small cam at *F* which is so designed that at alternate stopping positions the tails of pawl *C* are pressed downward, thus holding the pawls clear of ratchet *D*. This results in the motion of the eccentric *A* being transmitted to the feed rolls only once in every two revolutions of the crankshaft.

An additional device is provided for pinching the end of the bar, previous to its being fed into the dies, and this device is especially useful in the upsetting of square or hexagon bolt heads. In such cases the round bar would be pinched to a square or hexagon section; and with this section the corners of the bolt head can be well filled without getting a flash between the tool and dies. This pinching device is operated from a cam mounted on the lower cam-shaft on the right-hand side of the machine, as shown in Fig. 3. The roller lever operates a toggle joint which, in turn, slides a loose block in the backing plate, pinching the end of the stock and then moving away without remaining in contact with the hot bar any appreciable length of time.

Another feature of this machine is that it is so constructed that it may be changed to a single-blow machine and operated in that way by detaching certain parts and substituting

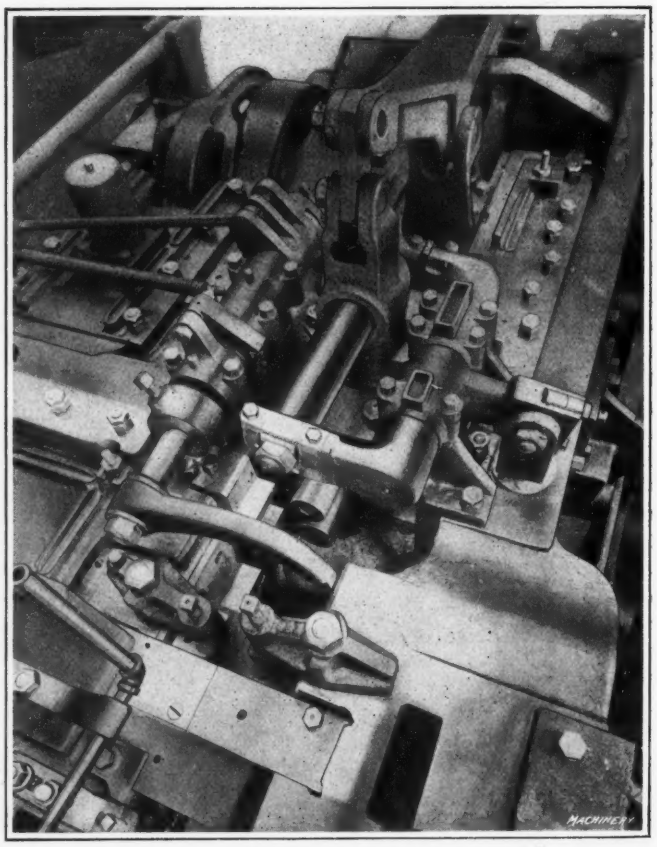
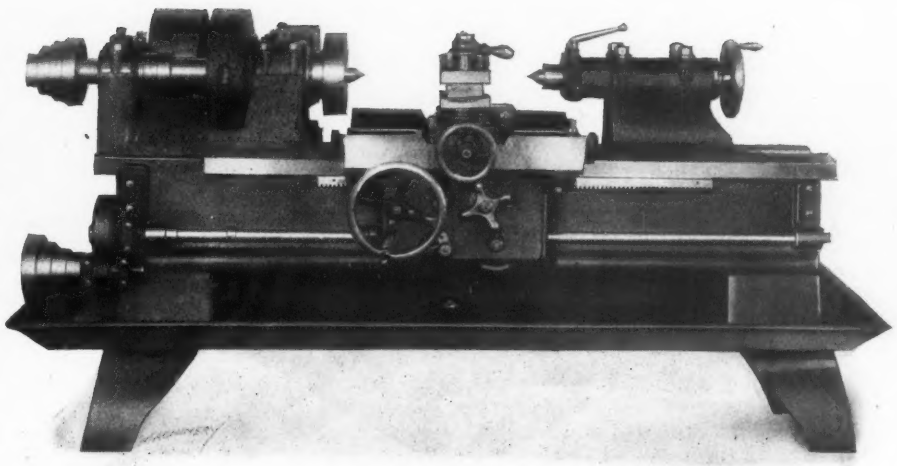


Fig. 5. View of Dies, Tools, Tool-holder Mechanism, Stock Gage, etc.

other pieces. In making the change a 1 to 1 gear drive is substituted for the 2 to 1 drive for operating the die-slide. Also, the die-slide cam and its shaft are replaced by a small crankshaft. The roller arm is replaced by a slide which is driven by the crank, and the change of gears to operate the die-slide leaves the lower camshaft disconnected. The tool-holder mechanism is disconnected at the top of the machine and a stationary tool-holder is bolted to the header-slide. The pinching device may be disconnected if desired, but it is useless as its cam does not move. The feed is made to act at every revolution of the crank by simply removing the pawl *E*, Fig. 3, and setting the cam *F* in such a position that it allows the pawl *C* to rotate the ratchet *D*. A kicker cam is provided to be put on the main crankshaft outside the left-hand bearing, for use when the machine is operated as a single-blow machine. This flexibility of usage is especially useful where there is not enough work to keep a two-blow machine busy all the time. The time required to make the change is only a few hours, and the machine operates perfectly as a single-blow machine.



Shook & Fletcher 20-inch Manufacturing Lathe, which is especially adapted for Shell Work

SHOOK & FLETCHER PROJECTILE TURNING LATHE

The Shook & Fletcher Supply Co., Inc., 827-830 Brown-Marx Bldg., Birmingham, Ala., is now manufacturing a projectile turning lathe which has a nominal swing of 20 inches over the bed. The noteworthy features of the machine are the exceptional driving power and strength that are provided, an idea of which will be gathered from the fact that the lathe will operate continuously on 0.45 per cent carbon forgings up to 10 inches in diameter, when taking a cut ½ inch in depth with a feed of 1/16 inch per revolution, at a peripheral cutting speed of 65 feet per minute. Working at this exceptionally high rate, it is stated that the machine shows absolutely no vibration or tendency of the bearings to heat; and the claim is made that the above figures do not represent the maximum capacity.

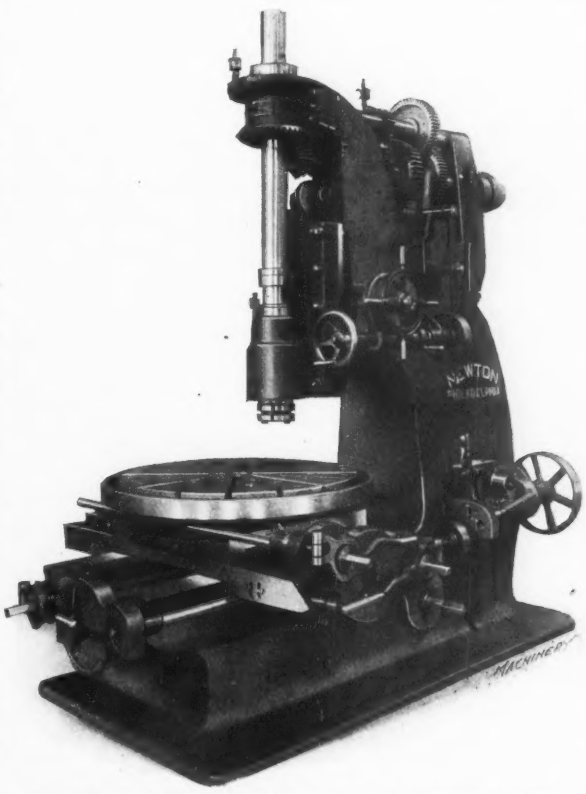
The machine is driven by a single pulley which is belted to a two-speed countershaft, and slip gears provide the necessary changes of speed. The spindle is made of 0.60 per cent carbon steel, ground to size and bored from a solid forging. The headstock bearings are lined with bronze bushings and alternate steel and bronze washers take the end thrust of the spindle. The carriage is provided with an oil trough around the front vee, which prevents lubricant from running down over the apron. The carriage is gibbed to the bed at the front and rear on the outside, and is also gibbed to the inside of the bed underneath the bridge, *i. e.*, the carriage is gibbed at four points so that it will not lift under any conditions.

The apron is of the double plate type which provides a bearing at both ends of all shafts, and the apron is tongued and grooved to the carriage. The feed friction is of large diameter and will pull the heaviest feeds without slipping. The knob for engaging the friction is provided with a pilot wheel 6 inches in diameter, which draws in the friction firmly without requiring undue effort from the operator. The machine is equipped with a four-step feed cone which carries a belt 1½ inch in width. The gear ratios in the feed mechanism are very high and ample power is provided for the heaviest feeds. When necessary a gear-box is provided which furnishes four changes of feed.

The principal dimensions of the machine are as follows: swing over ways, 20 inches; swing over carriage, 10 inches; capacity between centers for 7 foot 6 inch bed, 31½ inches; diameter of hole through spindle, 1⅜ inch; maximum travel of tailstock spindle, 8 inches; gear ratios, 8.5 to 1 maximum, and 2.85 to 1 minimum; available feeds per revolution, 0.020, 0.040, 0.060, and 0.080 inch; range of spindle speeds, 28 to 112 R. P. M. for 3- to 6-inch shells and 20 to 80 R. P. M. for 4½- to 9-inch shells.

NEWTON VERTICAL MILLING MACHINE

The accompanying illustration shows an improved type of heavy vertical milling machine, which has recently been added to the line of the Newton Machine Tool Works, Inc., Philadelphia, Pa. The feature of the machine is a flexible control which provides for the successful use of end-mills as small as ¾ inch in diameter on die work, and the cutters which can be used on the machine range from this size up to those required for performing the heaviest milling operations in locomotive shops. The illustration shows how well the design of the machine lends itself to the application of alternating-current motor drive, as changes are obtained through the speed-box gearing without requiring the removal of gears. Another feature is the counterweighted spindle saddle which is provided with vertical feed and fast power movement; reversing fast power traverse is also provided for the circular, in and out and cross table motions, which also have reversing power feed and means of making hand adjustment. All of these motions are governed from a centralized control.



Heavy Vertical Milling Machine made by the Newton Machine Tool Works

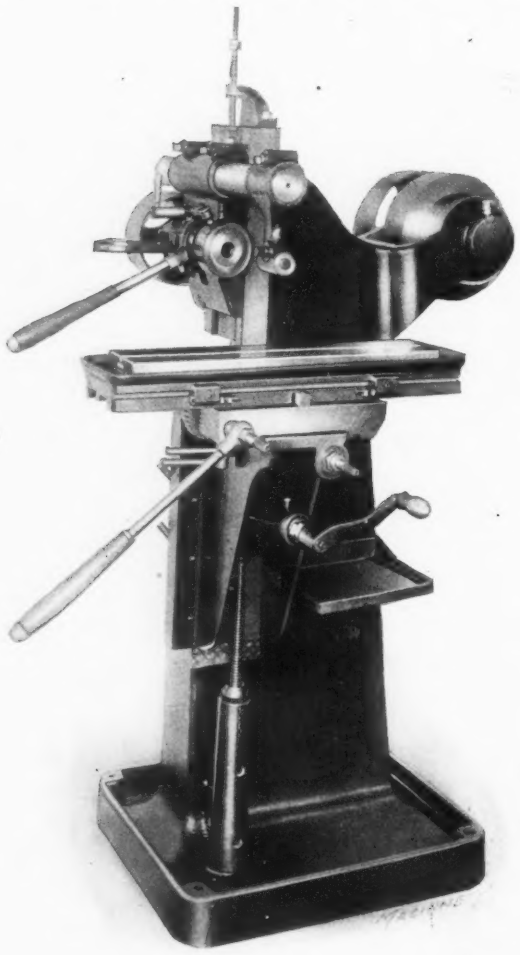
The important dimensions of the machine are as follows: diameter of circular table over slots, 42 inches; maximum cross feed, 30 inches; maximum in and out feed, 20 inches; range of spindle speeds, 8½ to 232 revolutions per minute; maximum diameter which can be milled when table is in its forward central position,

38 inches. The table is of the corner clamp construction, and is surrounded by a pan which is drained from the center. In conclusion, it may be mentioned that machines of this type have found successful application in milling the solid ends of shrapnel forgings, for which purpose the continuous circular feed motion provided on the machine is found most suitable.

KENT-OWENS MILLING MACHINE

The high-speed hand milling machine shown in the accompanying illustration is a recent product of the Kent-Owens Machine Co., Toledo, Ohio, and the P. H. Biggs Machinery Co., 809 Hippodrome Bldg., Cleveland, Ohio, has the sales agency. A feature of this machine is that it is equipped with Bock taper roller bearings for the spindle and back shaft. The machine may be run at speeds ranging from 1200 to 1500 revolutions per minute, which permits of the use of end-mills or "fish-tail" cutters as small as 3/16 inch in diameter. The high speed at which the machine may be operated makes it particularly suitable for milling splines.

The machine can be equipped with an oil pump and pan; and sufficient power is provided for driving two 3-inch straddle mills at a normal cutting speed. The clamping levers for the head are conveniently located at the front of the saddle; and all feed-screws have milled threads. The regular equipment furnished with the machine includes a countershaft and wrenches. A V-block for holding shafts which are to be splined, and a vise for general milling operations can be supplied as special equipment.



High-speed Hand Milling Machine sold by the P. H. Biggs Machinery Co.

The principal dimensions of the machine are as follows: Diameter of hole through spindle, 17/32 inch; taper of spindle, No. 9 B & S; maximum vertical travel of head by lever, 5 inches; over-all size of table, 8 by 26 inches; size of working surface of table, 5 by 17 inches; maximum distance from spindle to table, 14 inches; and maximum table feed by lever, 4 inches. By using a crank handle, the table has a maximum travel of 17 inches, and positive stops are located on the side of the table. The weight of the machine is 1800 pounds.

GORTON FUSE ROUTING MACHINE

The No. 8-B vertical milling machine shown in the accompanying illustration was designed by the George Gorton Machine Co., Racine, Wis., for routing the wrench slot in graze fuse bodies. The fuse body is mounted on a plug in the reciprocating work-holder and securely clamped by a half-turn of a knurled screw. The horizontal plunger locates the work from the percussion pellet hole. The work-holder is actuated by the reciprocating mechanism, motion being provided through an eccentric shaft and connection link. The spindle is made of hardened tool steel and runs in ball bearings; and a horizontal movement of two inches is provided by means of the lever at the right-hand side of the machine, a micrometer stop being provided which insures obtaining a uniform depth of slot on all pieces.

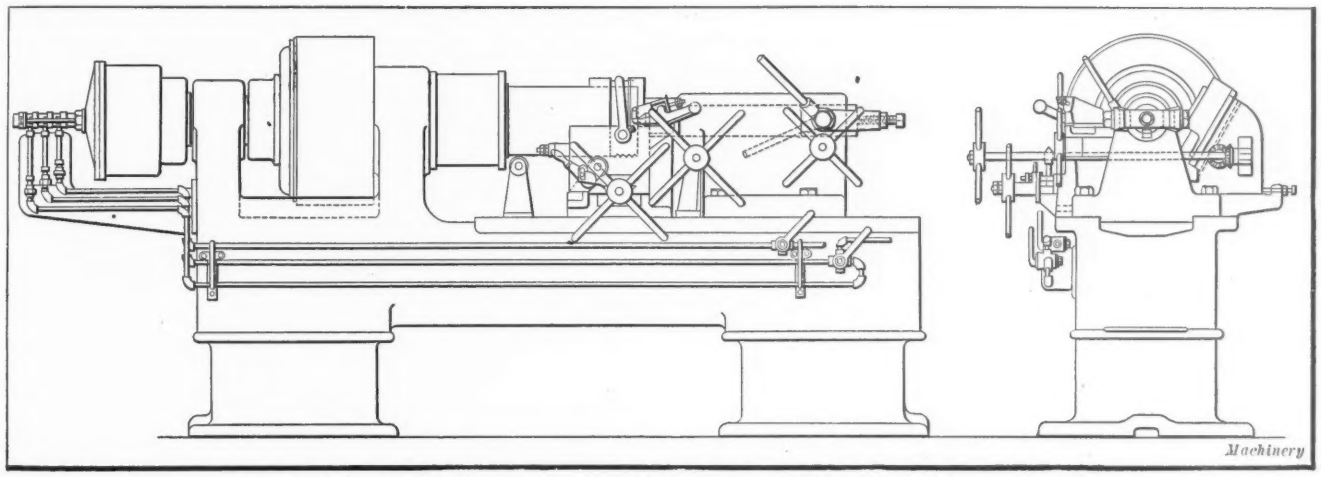
When changing cutters, a cutter gage is swung into position in front of the spindle to determine the exact position of the cutter; the cutter is then clamped in the collet and the gage dropped down out of the way. The countershaft is provided with ball bearings which are packed in grease; it is mounted on the machine and can either be driven from the lineshaft or by means of a motor carried by a bracket bolted to the under side of the shelf. It should run at approximately 2000 R. P. M., but this speed may be varied, according to the nature of the work. The tight and loose pulleys, which are 3⅛ inches in diameter by 1⅝ inch face width, are provided with ball bearings.

Gorton No. 8-B Vertical Milling Machine for routing Graze Fuse Bodies

This machine is equipped with a cutter lubricating system including a pump, tank, strainer, relief valve, flexible tube for delivering the lubricant to the cutters and all necessary piping. The pump is driven from the lineshaft and the lubrication flows from the work-holder into the lower portion of the cutter-head, from which it drains back into the tank. The tank is provided with a well, which extends to within a few inches of the top, and the chips are retained in this well so that they cannot be drawn into the suction chamber of the pump. The average rate of production is about 120 steel parts per hour and a correspondingly greater number of brass parts. The P. H. Biggs Machinery Co., 809 Hippodrome Bldg., Cleveland, Ohio, has the sales agency for this machine.

JENCKES BAND TURNING MACHINE

For use in turning the copper rifling band used on British high-explosive shells of the 8-, 9.2-, and 12-inch sizes, and corresponding sizes of Russian, French and Italian shells, the Jenckes Machine Co., Ltd., Sherbrooke, Quebec, Canada, has recently developed a single-purpose machine, which is



Jenckes Band Turning Machine equipped for machining Bands on British 9.2-inch High-explosive Shells

illustrated and described herewith. The illustration shows the machine equipped for operation on the 9.2-inch shells, and it will be seen that the bed is liberally proportioned to provide the necessary strength and rigidity to withstand the severe service conditions to which machines are put in the manufacture of ammunition. The bed is strengthened by box girths, and the spindle bearings are cast integral with the bed. The cap on the forward bearing is interlocked with the frame to provide for taking the end thrust, and both bearings are furnished with babbitt liners, which are peened in, bored and finally scraped to fit the spindle.

The tailstock may be located and bolted to the bed to suit any size of shell which is to be machined. The spindle is 5 inches in diameter and furnished with a heavy center. The spindle has a quick movement of about 6 inches which is actuated by a rack and pinion; its exact position is determined by a swinging stop at the rear which drops over the end of the spindle when it has advanced far enough. A limited adjustment is provided by means of a screw and lock-nut in the stop; this enables the center to act as a stop and also as a bearing for the shell, so that the band can be finished off exactly the correct distance from the end of the shell. The driving spindle is made of steel and carries a chuck which is built into the extension on the spindle. The chuck is of the collet type with jaws which are opened or closed by compressed air, the controlling valve being located close to the operator's right hand when he is in his customary position at the front of the machine. The drive is through a single clutch pulley 22 inches in diameter by 10½ inches face width; this pulley has bronze bushings and runs loose on the spindle. The clutch is the full diameter of the pulley and is of the taper cork insert type.

The tool base is bolted to the bed and carries both the roughing and finishing heads. In machining the 9.2-inch shells, the roughing operation is divided between two cuts. Each tool is fully adjustable but when once set, the tools can be removed and accurately replaced. The feed of both tools is provided by a single screw which works in connection with positive stops. The undercutting tool is carried on a separate block mounted on the front slide, and is set at the correct angle. The feed is through a lever end cam. The finishing tool is located at the rear and so mounted that the tool slides past the band and shears it to exactly the required size and shape. The feed is actuated by a rack and pinion operated by a handle which is conveniently located for the operator.

STUEBING ELEVATING TRUCK

The improvement of facilities for handling work in factories has received considerable attention during recent years, and one of the most important developments along this line has been the introduction of elevating trucks for use in connection with inexpensive platforms on which the work is stacked preparatory to moving it from one department to another. The chief advantage possessed by the elevating truck and platforms over the use of individual trucks is that the investment is materially reduced because it is merely necessary to buy a sufficient number of trucks for actually transporting the work through the factory.

The Stuebing Truck Co., Cincinnati, Ohio, is now manufacturing the elevating truck which forms the subject of the present description. It will be seen that this is a four-wheel truck and the frame is constructed entirely of steel, which combines the desirable properties of strength and lightness. The wheels are carried by roller bearings, which reduces to a minimum the amount of effort required to pull the truck. When the handle is raised to a vertical position, the platform

Fig. 1. Handle raised to lower Platform of Truck

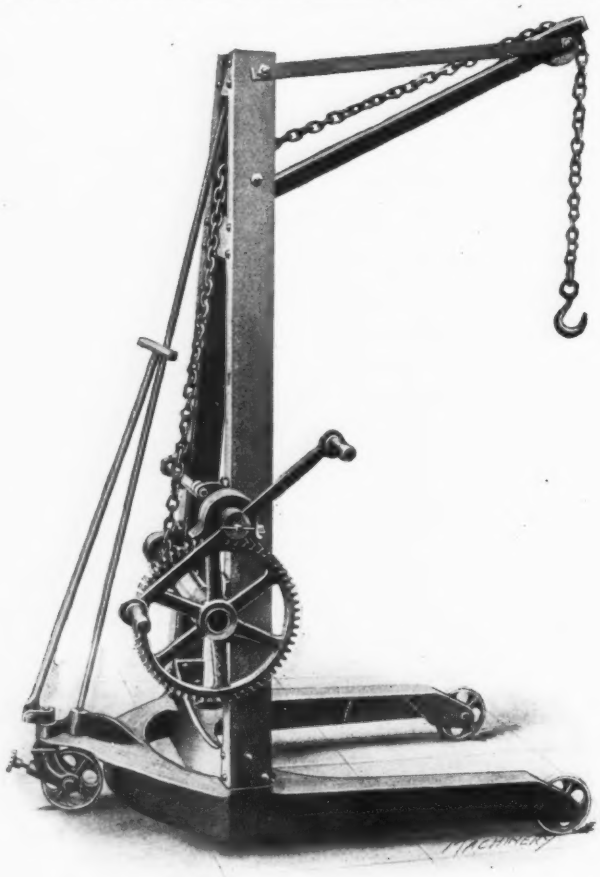
Fig. 2. Handle drawn forward ready to be released from Elevating Mechanism

of the truck is lowered, and when the handle is pulled forward the platform of the truck and the load are lifted by means of a hook which automatically disconnects, thus giving free use of the handle for pulling and steering the truck. The front wheels can be turned entirely around with the platform in the raised or lowered position, which permits of easy handling of the truck in close quarters or in making sharp turns.

A hydraulic check is provided for lowering the load, and by pressing a foot-treadle the load is released and lowered automatically under control of the hydraulic check. An important feature of this truck is that it is designed and constructed in such a way that it is an easy matter to make special trucks of any required width and length. The different sizes of trucks can be provided with wheels 6, 7 or 9 inches in diameter.

UNITED PORTABLE CRANE

The advantage of a portable crane for shop use is that it is capable of reaching all corners in the factory and eliminates danger of workmen straining themselves in an effort to lift heavy loads which cannot be handled by the regular traveling



Portable Crane made by the United Engine & Mfg. Co.

crane. The Manley "Hilite" portable crane which is a recent product of the United Engine & Mfg. Co., Hanover Pa., possesses the general advantages of portable cranes. In addition, the design has been worked out along lines which give this crane certain individual features. The superstructure is made entirely of steel, and it will be seen that the sections used are angles and channels which afford plenty of strength without making the crane unduly heavy.

The base is made of cast-iron with ribs to give additional strength. As the base is of heavier construction than the superstructure, it will be evident that the center of gravity of the crane is quite low, and as a result, the possibility of tipping it over has been materially reduced. The casters and front wheel support the base at three points so that a uniform bearing is obtained regardless of possible inequalities in the floor. All twisting strains are thus eliminated. The crane is locked by a hand-nut on the caster, which can be operated by the foot-treadle without stooping. These cranes are made in four different sizes which have lifts of 6 feet 6 inches, 7 feet, 7 feet and 8 feet. The two smaller cranes have a lifting capacity of 1 ton and an overhang of 33 inches, while the two larger cranes have a lifting capacity of 2 tons and an overhang of 38 inches.

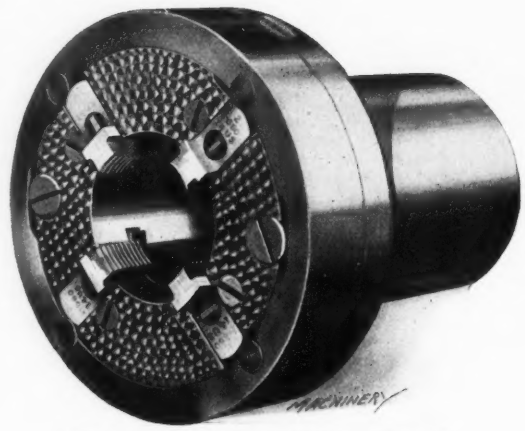


Fig. 1. National-Acme Adjustable Chaser Die

ADJUSTABLE CHASER DIE AND COLLET HOLDER FOR SPRING DIES

The National-Acme Mfg. Co., Cleveland, Ohio, has recently added to its line an adjustable chaser die that is adapted for use on all automatic screw machines and hand lathes. The chasers in this die are separate, so that they may be easily taken out and ground, and when the chasers are worn out they may be replaced. Another claim made for this tool is that in threading work over 1¼ inch in diameter, it can still be held extremely close to the required adjustment. The die has the same heavy one-piece body that is used in the National-Acme self-opening dies, and the chasers are held in accurate adjustment by a ring which has a bearing on hardened dowel pins seated against the backs of the chasers. Adjustment for tight or loose fitting threads is made possible by a screw in the side of the head, which operates on the principle of a micrometer gage after the screw holding the chasers has been loosened. To prevent side play, eccentric screws are turned against the sides of the chasers at the time the adjustment is made. These adjustable chaser dies are made in eight sizes which have capacities for threading work from 5/32 inch to 5½ inches in diameter.

The chief advantage claimed for the collet holder for spring dies which has recently been placed on the market by the National-Acme Mfg. Co. is that a bearing is provided for the lands of the spring die for their full length. This is the means of overcoming difficulty which is sometimes experienced in holding spring dies to exactly the required cutting size. When the required adjustment has been made by turning the master chuck, the collar at the back of the die is screwed up against the bottom of the chuck, thus making the adjustment secure and permanent. The back of the die is slotted to receive two pins for keeping it from turning in the holder; and the holder is furnished with the necessary float to compensate for variations in the spindle alignment when starting the thread. This collet holder is made in six sizes to accommodate dies for cutting threads on work from ¼ up to 1 inch in diameter. Using the National-Acme spring dies, one holder has a capacity for a wide range of work.

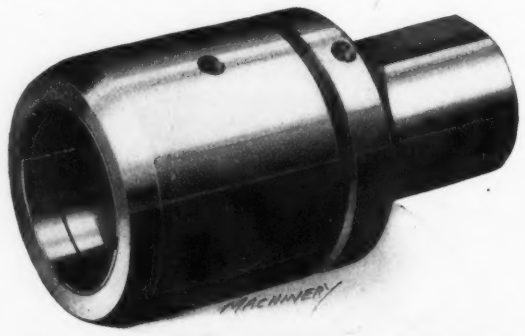


Fig. 2. National-Acme Collet Holder for Spring Dies

Fig. 1. Crescent Patternmakers' Bench Jointer

CRESCENT BENCH JOINTER

To meet the demand of patternmakers for a small jointer that can be set up on a work-bench, the Crescent Machine Co., 56 Main St., Leetonia, Ohio, has developed the tool shown in the accompanying illustrations. This machine is provided with a 4-inch head, which has ample capacity for most of the work handled in average pattern shops, and the percentage of work which can be done on this little jointer is further increased by the fact that most pattern work is relatively short. Having the jointer right on the work-bench, instead of having to carry the work to a machine, is naturally the means of saving a considerable amount of the patternmaker's time. The head of the machine is 4 inches wide and the overall length is 20 inches. It can be furnished with individual electric motor drive or belted to a countershaft according to the requirements of different shops. The design has been worked out along lines which provide ample strength for the work for which this machine is intended.

SKATE SHARPENER

It is a matter of general knowledge that a satisfactory skate sharpener must hold the blade in such a manner that it may be fed evenly along the face of the grinding wheel. This requirement has been fulfilled in the skate sharpener which has recently been developed by the Luther Grinder Mfg. Co., Milwaukee, Wis. This company is making three different skate sharpening outfits. One of these consists of a grinding machine which is driven by foot-treadles and equipped with a skate grinding attachment; the other two consist of skate grinding attachments furnished for the use of those who already have the Luther foot-power grinder or the Luther power-driven bench grinder. The feature of the attachment is its extreme simplicity. It consists of two C-shaped clamps which hold the skate that is to be ground, and a metal baseplate. The method of using the attachment is so simple that it can be readily operated by any mechanic of average intelligence.

NEWTON PROFILING MACHINE

The accompanying illustration shows a profile milling machine which is a recent product of the Newton Machine Tool Works, Inc., Philadelphia, Pa. The design includes certain improved features which facilitate the rapid production of accurate work. The spindles are mounted on separate slides provided with vertical hand adjustment, and are carried by double tapered bronze bushings which have means of adjustment for wear. Each spindle slide is supported on a stout spring which acts as an automatic saddle return; the vertical movement of either spindle is controlled by the hand-lever at the right-hand side of the spindle, and the extreme limit of the vertical movement in either direction is controlled by adjustable limit stops.

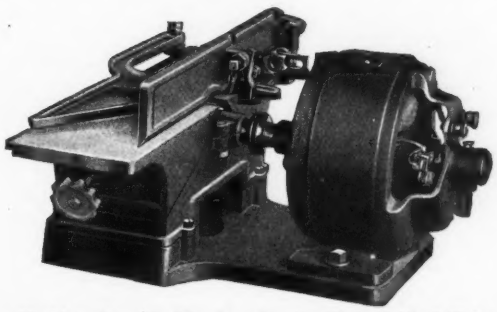
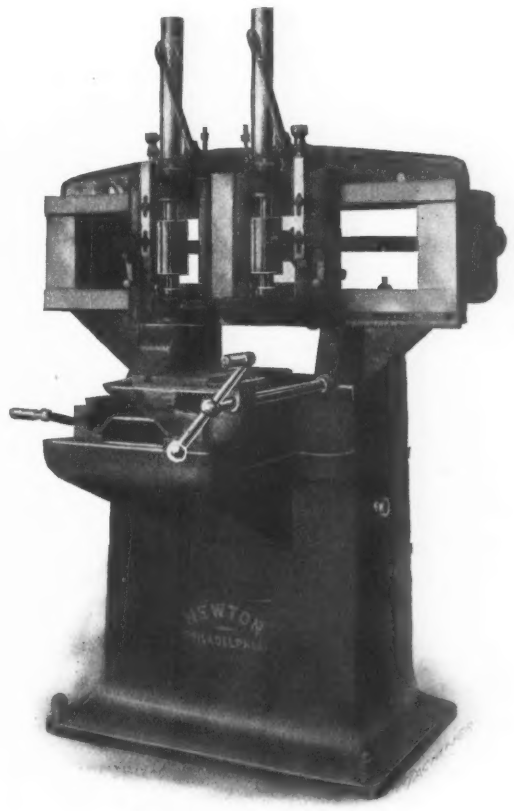


Fig. 2. Machine shown in Fig. 1 equipped with Individual Motor Drive

The duplication of parts which have faces to be finished at two or more elevations is facilitated by the use of removable master gage strips which are notched to engage a latch to provide the proper location for each surface on the work. A clamp is provided for locking the spindle saddle in any position when such a procedure is found desirable. The pilot on the duplex saddle is guided across the master former by means of a hand-lever, which controls the compound spur gears that transmit motion to the pinion meshing with the rack on the bottom of the saddle; and for lengthwise operations, the table to which the master former and work are attached is moved through compound gears controlled by the other hand-lever on the machine.

The spindles are driven direct from the countershaft by continuous belts which are guided by sliding idler pulleys. Two spindle speeds are provided which are 840 and 1200 R. P. M. It will be seen that the table has two T-slots and is surrounded by a lubricant pan arranged with drains leading to a central reservoir at the rear of the machine. The principal dimensions are as follows: Maximum distance from end of spindles to table, 5½ inches; minimum distance from spindles to table, 3 inches; fixed distance between spindle centers, 12 inches; size of table, 12 by 15 inches; width between uprights, 19 inches; and maximum table movement, 21½ inches.



Newton Profile Milling Machine

NEWTON BORING, TURNING AND FACING MACHINE

For use in machining a new automobile rear axle member the Newton Machine Tool Works, Inc., Philadelphia, Pa., has recently developed a boring, turning and facing machine which is illustrated and described herewith. It will be seen that this tool is provided with individual cross and longitudinal saddle feeds, with positive turret feed stops which give four positions to the longitudinal and two positions to the cross feed. The turrets have circular adjustment and six stations; they are arranged to carry the Acme type of removable tool-holders. The spindle head is equipped with a Horton three-jaw universal chuck at each end, which has sufficient capacity for holding work up to 12 inches in diameter. The

drive is transmitted to the spindle through a large bronze spiral gear and hardened steel pinions from the three-step cone pulley shown in Fig. 2.

Motion for all saddle movements is taken from the main pulley shaft and transmitted to a gear-box which has a 5 to 1 ratio. The changes are obtained in this box without requiring the removal of gears; and all motions are independently clutched by hand-levers, while the release is effected by dogs on the saddles which engage adjustable stops set in the proper positions. The turrets are 18 inches in diameter on the working surface, and the maximum distance between the turrets is 6 feet 6 inches. This machine is also well adapted to the requirements of simultaneously trimming the closed ends and cutting excess metal from the open ends of two shells up to 12 inches in diameter; and under suitable conditions it may also be employed for performing the contour boring operations on the inside of the shells.

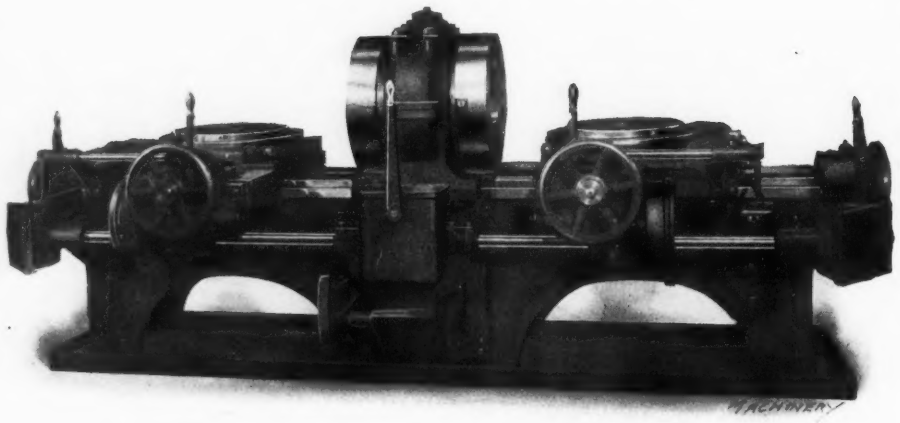


Fig. 1. Newton Turning, Boring and Facing Machine

RICHARDSON-PHENIX CUTTING OIL FILTER

The increase in the use of automatic machine tools, the high speeds at which cutting tools are operated, the necessity of obtaining greater accuracy and exact duplication of parts, and the increased cost of labor and raw materials, have made it necessary for manufacturers to adopt more efficient methods of using cutting oils and compounds. As a matter of fact, there is no reason why the lubrication of cutting tools should not be done just as efficiently as any of the other work in the factory, and in progressive manufacturing plants this improvement in the application of cutting oil has already been accomplished.

In its simplest form, a modern cutting oil circulating and filtering system operates as follows: Clean cutting oil or compound contained in an overhead reservoir is carried by gravity through a system of piping to the various machine tools, and applies lubricant not only to the cutting tools but also to the bearings on the machines. The lubricant is generally delivered to each machine through a flexible metal hose, and a control valve is provided at each machine. The used lubricant is carried by gravity into the filter, where it is thoroughly purified; and this filter is so designed that it removes all scale, sand, metal chips, etc., and, when necessary, the oil is also sterilized so that it will be free from bacteria.

It is a well established fact that the use of pure cutting oil more than pays for the expense of purification, and the following outlines some of the advantages which have resulted from the use of pure oil in place of oil contaminated with chips and other foreign matter. In one factory it was found that cutting tools and drills lasted from one-third to two and a half times as long when lubricated with pure oil in place of dirty oil. In another factory difficulty was experienced from the foreign matter carried by the oil causing the sides of drills to wear down, thus producing a tapered drill which had a tendency to wedge in the work. This condition also gave trouble through the drill's generating an excessive amount of heat, interfering with the accuracy of the work and requiring an unnecessary amount of power to drive it. The use of clean oil removed the cause of the trouble and no further difficulty was experienced.

In a shop working on cast iron, the sand and scale carried by the oil were responsible for the rapid wearing down of the cutting edges of the dies and taps, which made it necessary for these tools to be sharpened at frequent intervals. Here, again, the cause of trouble was removed by using clean oil, which effected a saving in power in addition to reducing the cost of tool maintenance. In still another factory a large amount of time was lost owing to the sediment in the cutting oil interfering with the operation of self-opening dies. The use of filtered oil eliminated this tendency of the dies to stick, with the result that the output was materially increased.

Another advantage obtained from the application of a circulating oil system is due to the reduction of fire hazard. The danger of having large bodies of cutting oil around each machines is apparent, but this danger is practically eliminated where an automatic circulating system is employed, because the oil fed to each machine is carried off by the drain pipe as fast as it is delivered to the cutting tools. The only oil kept in the base of the machine is the small quantity adhering to the machine and to the chips, which is not sufficient to support a fire. Where the reduction of fire hazard is an important matter, the oil storage reservoir and filter may be put in a fire-proof compartment that is located at a distance from the main buildings.

Practically every manufacturer realizes the advantages of using a good grade of oil on machine tools. The matter of expense is not so important when an automatic circulating and filtering system is installed, because the cutting oil really becomes an investment and is used over and over again. The advantage obtained from using good clean oil for lubricating the bearings of machine tools is too obvious to require discussion. The Richardson-Phenix Co., Milwaukee, Wis., has recently brought out a line of filters which are especially designed for purifying cutting and lubricating oils, and the accompanying illustration shows one of these filters that has a magnetic separator for use in plants working on iron or steel. The following outlines the principle on which this equipment operates:

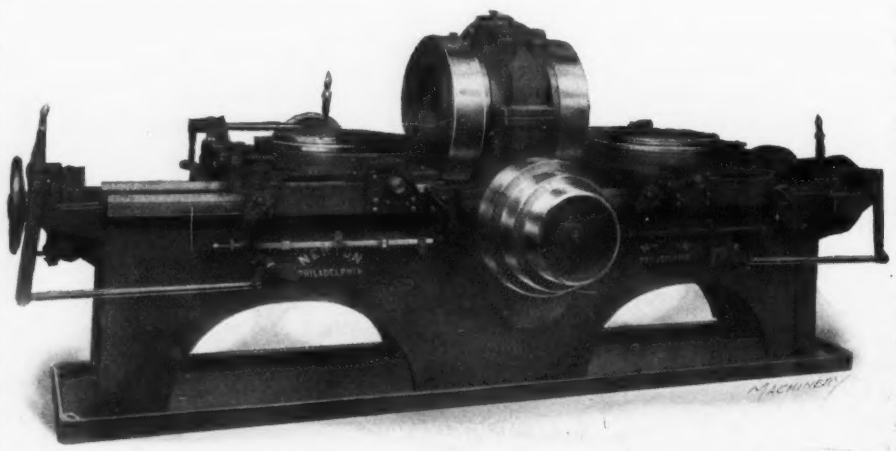
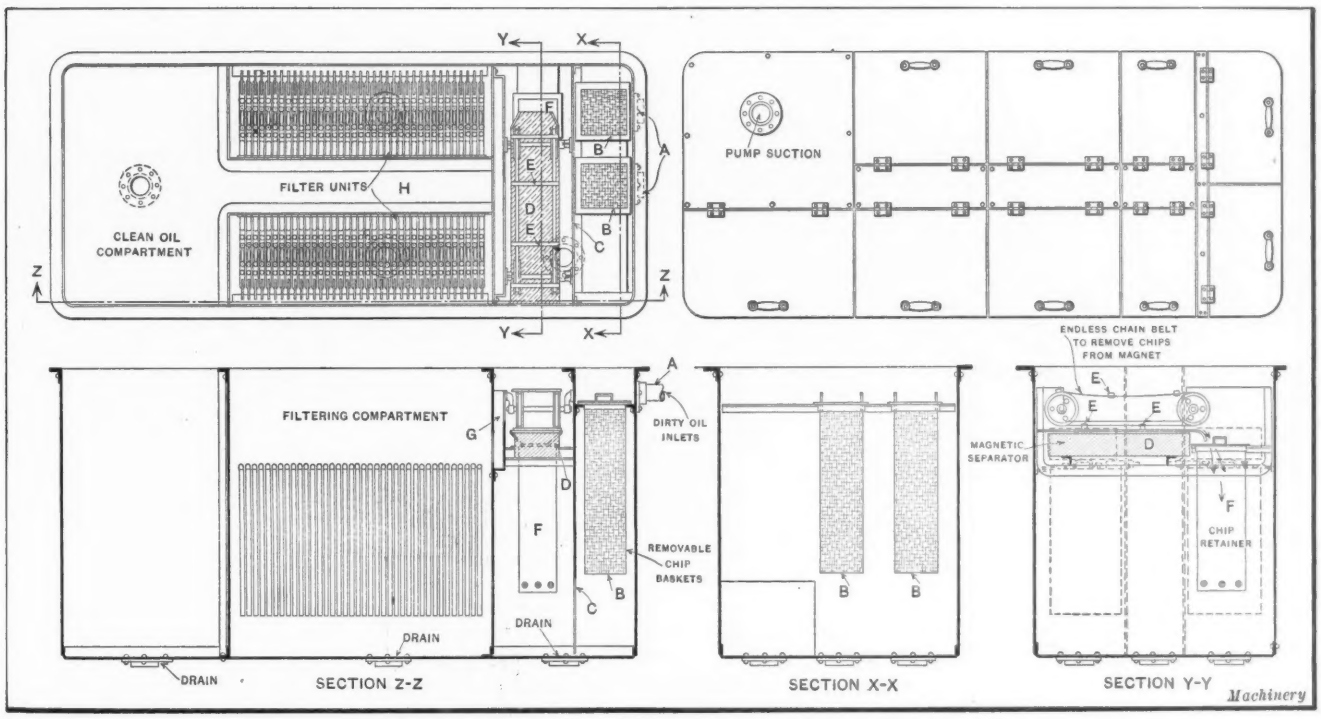


Fig. 2. Opposite Side of Newton Machine shown in Fig. 1

Used oil flows through the inlets *A* and passes down through strainer baskets *B* which remove the large chips. The oil then flows under the baffle plate *C* and



Richardson-Phenix Cutting Oil Filter, showing Method of Operation

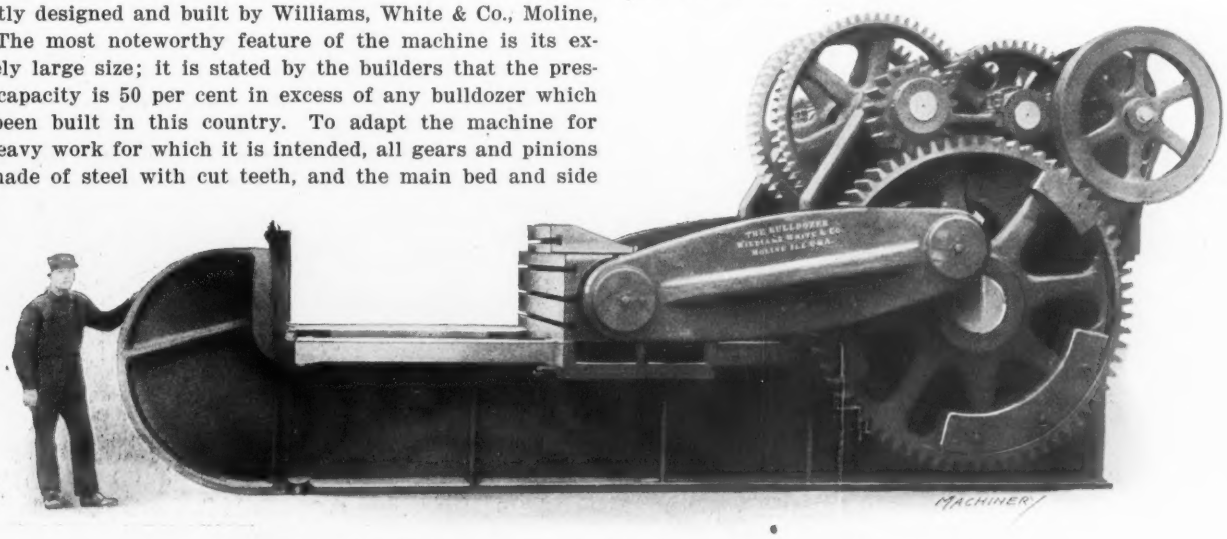
up over the top of magnetic separator *D*, where iron and steel chips are removed from the oil. The accumulation of chips on the magnetic separator is removed by scrapers *E*, which are carried by an endless chain belt and travel across the face of the magnet to provide for scraping the chips off into retainer *F*. This retainer is provided with holes at the bottom which are covered by screens to allow the oil to drain out. Referring to the cross-sectional view on line Y–Y, it will be seen that the chip retainer can be slid to the right and lifted out to enable the chips to be removed.

After passing the magnetic separator, the oil flows over dam *G* into the filtering compartment, from which it passes through individual filtering units that remove the most minute particles of foreign matter. The clean oil collects in compartment *H*, from which it is pumped to the overhead reservoir ready to be once more delivered to the cutting tools. If the use of an overhead reservoir is objectionable, the clean oil can be pumped directly into the oil distributing pipes, a relief valve being provided to maintain the required pressure. The cutting oil filters built by the Richardson-Phenix Co. are made in a number of different types to meet various service conditions, and for use with all kinds of oils.

WILLIAMS-WHITE BULLDOZER

The No. 30 bulldozer illustrated and described herewith was recently designed and built by Williams, White & Co., Moline, Ill. The most noteworthy feature of the machine is its extremely large size; it is stated by the builders that the pressure capacity is 50 per cent in excess of any bulldozer which has been built in this country. To adapt the machine for the heavy work for which it is intended, all gears and pinions are made of steel with cut teeth, and the main bed and side arms are of cast steel. A large steel shaft is fitted through the sliding casting, the ends of which serve as trunnions.

Power is provided by a 75-horsepower electric motor which is direct-connected to the machine. It will be seen that the motor is carried on a bracket bolted to the housings. This bulldozer is provided with forward and reverse gearing, both movements being controlled by friction clutches. T-slots are provided in the cross-head and the end lugs are furnished with tapered gibs for adjusting the dies. An idea of the size of the machine will be gathered from the overall dimensions which are 26 feet long by 12 feet wide. The pressure capacity is 500 tons. This type of machine is being successfully employed for forging shrapnel and high-explosive shells, and produces a uniformly smooth and accurate shell forging.



Bulldozer built by Williams, White & Co., which has a Pressure Capacity of 500 tons

"MOSHER" ADJUSTABLE DRILL BRACE

The "Mosher" adjustable drill brace which forms the subject of this description is made by the Adjustable Drill Brace Co., 100 High St., Boston, Mass., and is designed for the same class of work as a drill-post or "old man." The features of the Mosher drill brace are the pivoting post, the lightness of the tool, and the fact that it can be manipulated without requiring the use of wrenches. The brace is made of steel tubing and is so constructed that it may be easily taken apart and put in the tool chest.

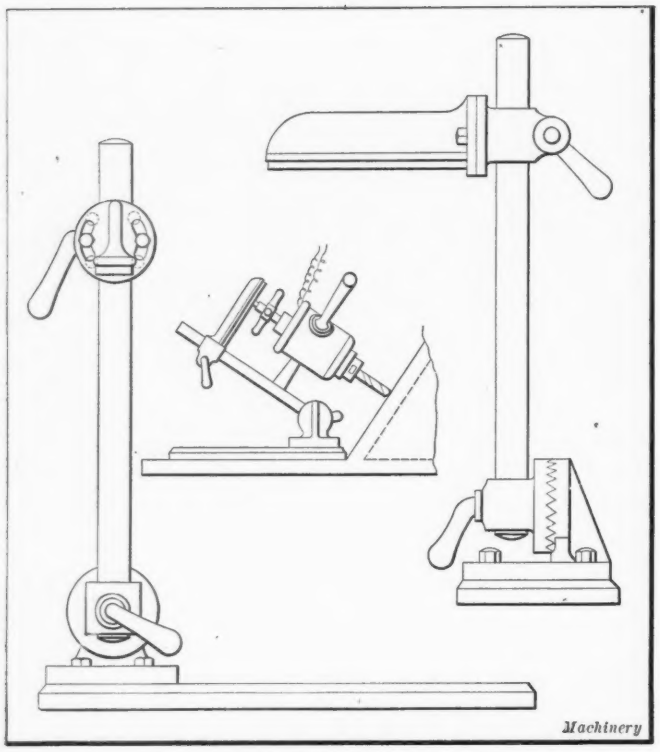


Fig. 1. "Mosher" Adjustable Drill Brace

Fig 1 shows the design of the tool and one of its numerous applications is illustrated in Fig. 2. The brace is made in three different sizes, which are known as Nos. 1, 2, and 3. The No. 1 brace weighs 16 pounds and is intended for use in connection with a small ratchet, air drill or electric drill. The post of this tool is 1⅛ inch in diameter and the arm is 8

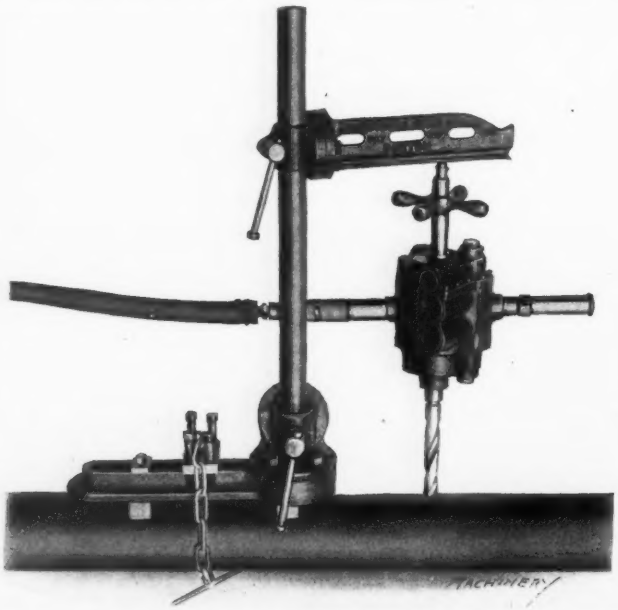


Fig. 2. No. 2 Adjustable Drill Brace used with Pipe Drilling Attachment

inches in length. The No. 2 brace is especially adapted for general machine shop and construction work. It weighs approximately 36 pounds, the diameter of the post is 1½ inch and the length of the arm is 11 inches. The No. 3 brace is adaptable for heavier classes of drilling. It weighs 52 pounds, the post is 2⅛ inches in diameter and the length of the arm, 15 inches. The pivoting feature enables the post to be set at the angle most suitable for the work, and means are provided for clamping the tool rigidly in this position.

I. O. C. OXYGEN AND HYDROGEN GENERATOR

The demand for oxygen and hydrogen for various industrial uses has grown very rapidly in the last five years. Certain lines of manufacture have been built up around the oxygen process of welding, such as welded tanks, steel barrels, automobile parts, tubes, etc., while for repairing broken machinery, for reclaiming castings, and for metal cutting of every nature, oxygen and hydrogen or oxygen and acetylene are used in steel mills, railroad shops, foundries and down to the smallest machine shop. Hydrogen likewise is in active demand. It is used more and more for cutting purposes, and for light welding; it is also used for lead burning, platinum smelting, in the manufacture of filaments for electric lamps, and to a very great extent in the new industry of hardening oils by the hydrogenation process. This rapid development in the uses of the two gases was facilitated by the introduction into this country of oxygen and hydrogen generating apparatus several years ago. Large users of one or both of these gases were thus enabled to obtain their supply direct from their

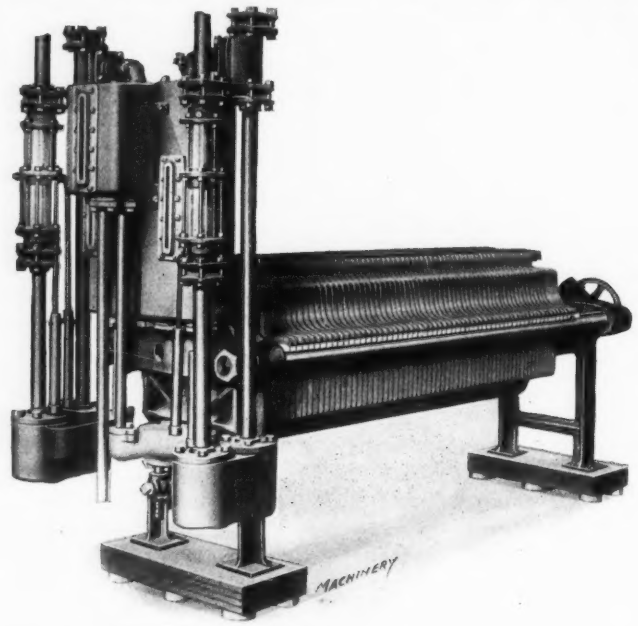


Fig. 1. I. O. C. Bipolar Oxygen and Hydrogen Generator

own generating plant at low cost, in a manner suitable to their individual requirements.

In the field of oxygen and hydrogen generating equipment, the International Oxygen Co., 115 Broadway, New York City, has set a standard for apparatus of workmanlike design and

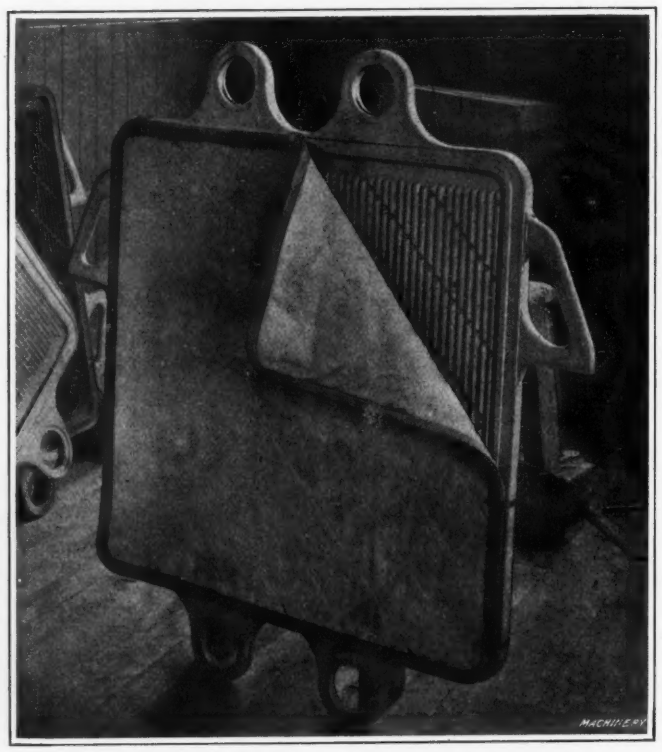


Fig. 2. An Electrode and Diaphragm from I. O. C. Bipolar Generator

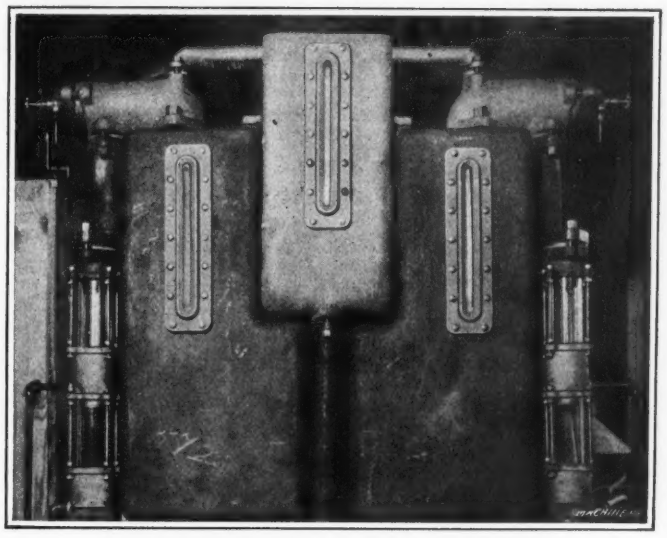


Fig. 3. Close View of Water Tank and Gas Domes

security of operation. The type of machine manufactured by this company known as the "I. O. C." unit type, is recognized as an efficient and high-class apparatus, and is in successful operation in numerous plants throughout the country. Today, the International Oxygen Co. is bringing out a new style oxygen and hydrogen generator under the name of the I. O. C. bipolar generator. This type of generator resembles outwardly a filter press such as is used in many chemical industries. Moritz, of Wasquehal, France, patented this type of apparatus in the United States and elsewhere, and I. H. Levin of the International Oxygen Co., who studied under Moritz and Flamand, perfected this machine.

Briefly described, the I. O. C. bipolar generator consists of a series of metallic plates (electrodes) clamped together in a heavy frame, electrically insulated from one another, and separated by diaphragms of porous fabric. Each pair of these electrodes forms a closed cell, divided by the diaphragm. These cells are filled with the electrolyte (caustic potash or soda) which acts as a conductor. An electric current admitted at one end plate passes on through the plates and the solution to the other end plate. In its passage, the current decomposes the water in the solution into the two gases—oxygen and hydrogen—which are released on opposite sides of each plate and emerge upward into the gas off-takes. The mingling of the oxygen and hydrogen in each cell or compartment is prevented by the diaphragm which, while permitting the passage of the fluid resists the passage of the gases, according to a well-known physical law. As the gases are released and withdrawn, the solution is automatically replenished from a supply tank. The operation is continuous so long as the current and electrolyte are supplied.

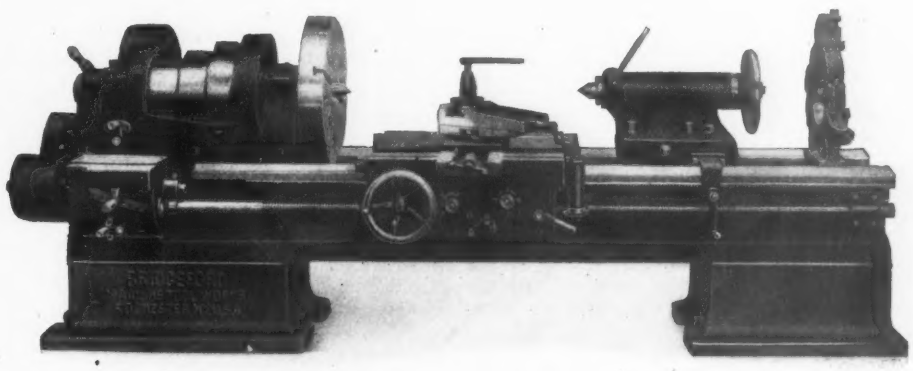
The two gas off-takes discharge into the two independent gas domes illustrated in Fig. 3, the gas emerging below the fluid surface through an inverted "U." It is apparent, then, that the pressure on both gases, clear back to the individual cells, is the same, being that determined by the hydrostatic head in the domes through the two independent risers from the water-feed manifold. This balanced pressure in both gas off-takes forbids any mixture of the gases and contributes to the balancing of pressures on the diaphragms. It will be noted that gas and water pressures are predetermined and constant. The gases, escaping from the gas off-takes, rise through the fluid in the gas domes and pass out through discharge pipes at the top of the domes, thence downward to purgers on each side. These purgers are closed boxes of cast iron filled with water to a certain level. The gases escape below the surface of this water, pass upward through it, and emerge thence through the supply lines to the gas holders. The function of these purgers is threefold: first, to catch any entrained fluid in the gas; second, to cool the gas; third, to act as a watercheck valve protecting the pressure system of the generator from any undue pressure of the gas holders. The gases produced are extremely pure. The oxygen has a purity of 99.6 per cent, and the hydrogen of 99.8 per cent.

BRIDGEFORD HEAVY-DUTY LATHE

In developing its new 26-inch cone-driven lathe, the Bridgeford Machine Tool Works, 225-227 Mill St., Rochester, N. Y., has made several noteworthy improvements. Among these may be mentioned the provision of further reinforcement for the bed by employing a center rib; and this rib carries a rack with which a pawl at the rear of the tailstock may be engaged when the lathe is employed on heavy work. The lathe can be furnished with either a three- or four-step cone pulley; a 5-inch belt is used on the three-step cone, and a 4-inch belt on the four-step cone. The apron is of the double-wall type, providing double supports for all shafts, gears and pinions. The machine is double back-geared, nine speeds being available with the three-step cone, and twelve with the four-step cone. By substituting a suitable sleeve and gearing for the cone pulley, variable-speed motor drive may be employed.

The headstock is provided with heavy bronze bearings, and the spindle bearings are self-oiling. The spindle is of high-carbon steel, ground to size, and has a hole 2⅛ inches in diameter. The tailstock is designed to clear the compound rest when the lathe is employed for turning angular work, and is so arranged that it may be set over for taper turning operations. Two heavy binders are provided for clamping the tailstock in position. The carriage, compound rest and apron are heavily constructed and the direction of feed is changed at the apron. Both lateral and cross feeds are driven by independent frictions, and an interlocking device in the apron prevents simultaneous engagement of the lead-screw and feed. Standard equipment furnished with the machine includes large and small faceplates, compound rest, center rest, standard change-gears, self-oiling countershaft and wrenches. A taper attachment, side turning rest, follow-rest, thread indicator, quick-change gear attachment, or special large center rests may be obtained as extra attachments.

This lathe is particularly adapted for the most severe classes of service, and is provided with ample power for removing metal rapidly and accurately. To meet these requirements all parts are liberally proportioned. The following are the principal dimensions of the machine: Swing over ways, 27 inches; swing over carriage, 19 inches; distance between centers for 12-foot bed, 6 feet; range of spindle speeds, 6 to 260 R. P. M.; range of threads that may be cut, 1 to 14 per inch or 2 to 28 per inch; size of front spindle bearing, 4½ by 7½ inches; size of rear spindle bearing, 3¼ by 5⅜ inches; diameter of hole through spindle, 2⅛ inches; diameter of tail spindle, 3 15/16 inches; dimensions of lead-screw, 1 15/16 inch in diameter by 2 pitch, and weight of lathe with 12-foot bed, approximately 8000 pounds.



Bridgeford 26-inch Heavy-duty Cone-driven Lathe

NEW MACHINERY AND TOOLS NOTES

Nut Die: Mummert-Dixon Co., Hanover, Pa. A nut die for use in re-threading studs on which the thread has become bruised. The use of this die enables the stud to be re-threaded without removing it from the machine.

Cast Vanadium Steel Die-blocks: Sivyer Steel Casting Co., Milwaukee, Wis. Cast vanadium steel die-blocks which are said to be suitable for use in place of hammered carbon steel blocks in making dies for a great variety of purposes.

Soft Metal Hammer: Bauth Mfg. Co., 901 Gerke Bldg., Cincinnati, Ohio. A soft metal hammer adapted for general machine shop use, and also for use in sheet metal shops, garages, and other places where such a hammer is necessary.

Alligator Shear: Doelger & Kirsten, Milwaukee, Wis. A machine adapted for service in warehouses and mills for cutting bars, angles, flats and rounds. The shear is equipped with an automatic stop and is made with 12, 18, 21 or 24 inch blades.

Oil Grooving Attachment: Cleveland Machine Tool Works, Cleveland, Ohio. An oil grooving attachment for use on the horizontal boring machines of this company's manufacture. The attachment provides for cutting internal or external oil grooves.

Bench Vise: Luther Grinder Mfg. Co., Milwaukee, Wis. This vise is intended for light assembling work and is not a general-purpose vise. An attachment is provided for use in the vise which adapts it for handling pipes, tubing and other cylinder work.

Electric Welder: National Electric Welder Co., Warren, Ohio. An automatic electric welding machine for welding rings. The machine takes No. 11 wire from the coil and automatically welds, forms and cuts off the rings at the rate of 60,000 per day.

Pressed Steel Truck Wheel: W. J. Clark Co., Salem, Ohio. The advantages of this truck wheel are that it is extremely light and still provides the necessary strength for supporting the maximum rated loads of the different types of trucks for which it is intended.

Electric Hoist: Dake Engine Co., Grand Haven, Mich. A hoist equipped with the usual form of crane hook, and two wire ropes wound on individual drums. The hoist is made in two styles, one of which has a hook suspension while the other is equipped with a trolley to run on a rail.

Portable Electric Drill: Standard Electric Tool Co., Cincinnati, Ohio. A drill made in 3/16, ¼, and 5/16 inch sizes, which weigh 6, 7, and 8 pounds, respectively. The two smaller tools are fitted with three-jaw geared chucks, and the largest size with a two-jaw screw chuck.

Test Indicator: William H. Simpson, 30 Church St., New York City. A test indicator which can be readily attached to a surface gage or caliper. Each graduation represents 0.001 inch. The instrument is fitted with a hardened steel contact point and the working parts are protected by a case.

Portable Air Compressor: Zin-Ho Mfg. Co., 1324 Michigan Ave., Chicago, Ill. This unit consists of an air compressor driven by a gasoline engine. The entire outfit is mounted on a four-wheeled truck so that it may be pulled about the shop to supply compressed air at any point where it is required.

Pattern Shop Miller: Oliver Machinery Co., Grand Rapids, Mich. A vertical milling machine for use in the making of wooden patterns. The machine is adapted for a great variety of operations, and by using a dividing head it will be found particularly useful for making gear patterns and similar work.

Portable Crane: Zinke Co., Inc., 1322 Michigan Ave., Chicago, Ill. The distinctive feature of this crane is that it has no chains, the load being raised by raising the arm in its vertical support. This raising of the arm is effected by means of a crank which turns the elevating screw through a train of gears.

Universal Right-angle Drive: Diamond Clamp & Flask Co., Richmond, Ind. A joint which consists of a series of universal joints that are connected. These joints are contained in an oil-tight elbow and run in oil. The device may be used in place of gears or quarter-turn belts, and effects a considerable saving of space.

Shop Truck: Orenstein-Arthur Koppel Co., Koppel, Pa. An electric shop truck made in various sizes, and known as the "Electromobile." Four helical steel springs support the frame, which have sufficient carrying capacity so that they will not be fully compressed under the full load for which the truck is adapted.

Electric Grinder: Standard Pattern Works, Erie, Pa. A small electric grinder designed for use in pattern and woodworking shops, and also in machine shops and tool-rooms. The table of the machine may be set in an inclined position at any angle between horizontal and 45 degrees, to provide for grinding beveled work.

Shaft Coupling: Coronum Equipment Co., 110 Fulton St., New York City. This shaft coupling consists of three essential parts which are a split sleeve and two coupling members. The sleeve is tapered to fit the couplings and when the latter are screwed upon the tapered sleeve, compression is obtained for securing the shaft.

Belt Tightener: Cleveland Fabric Belting Co., 1473 W. 110 St., Cleveland, Ohio. A device for use in taking the slack out of belts ranging from 1 to 36 inches in width. It consists of clamps applied to either end of the belt which are drawn back to secure the required tension, after which the ends of the belt are cemented together.

Acetylene Generator: Metals Welding Co., Cleveland, Ohio. An acetylene generator in which every seam and fitting is welded. The motors used to operate the feeding mechanism are controlled by a sensitive diaphragm regulator which affords an even pressure on the gas and assures delivering an accurate supply of carbide to the generator.

Oil Cleaning Machine: De La Vergne Machine Co., New York City. A tank for use in washing oil which has been used in bearings. The oil to be cleaned is introduced into the tank which is about half filled with water, resulting in the impurities separating out in the form of a sludge which collects in a layer between the oil and water.

Hydro-pneumatic Press: Metalwood Mfg. Co., Detroit, Mich. A type of press designed for use in conducting physical tests on 105, 120, and 149.1 millimeter high-explosive shells. In conducting these tests an internal pressure is applied to the inside of the shell, and it is for the development of this pressure that the presses are employed.

Arbor Press: Special Tool Co., West Hancock, Mass. An arbor press equipped with a V-plate having a series of holes on both sides. The design is such that any of the holes or any section of the slot can be placed directly under the ram without detaching the plate from the press. The ram is actuated by a hand-operated rack and pinion.

Electric Butt Welder: Detroit Electric Welder Co., Detroit, Mich. The important feature of this machine is that it is equipped with an improved form of equalizing clamp for holding stock which varies slightly in size. The machine is constructed in such a way that a single movement of a foot-treadle clamps both pieces which are to be welded.

Portable Grinding Machine: Stow Mfg. Co., Binghamton, N. Y. A grinder which is driven by a flexible shaft that receives power from an electric motor mounted on a truck. From this it will be evident that the entire outfit may be easily transported to provide for taking the wheel to the work instead of having to bring the work to the wheel.

Vertical Milling Machine: George Gorton Machine Co., Racine, Wis. A vertical milling machine particularly adapted for grooving the timing rings for shrapnel shell fuses. This is the Gorton vertical milling machine equipped with a special work-holder and set by automatic stops to insure the rapid production of duplicate work. One operator can attend to two machines.

Shear: Danville Foundry & Machine Co., Danville, Pa. The important feature of this machine is that the knives are so driven that a dwell is provided at the top of the up-stroke to allow ample time for putting the material in place ready for the next shearing operation. The capacity of the machine is up to 3-inch rounds, and the rate of production twenty cuts per minute.

Shell Grinding Machine: Guy G. Townsend, Winchendon, Mass. A machine equipped with hand feed, which is particularly adapted for grinding shrapnel and high-explosive shells. The wheel is 20 inches in diameter by 4 inches face width, and stops are provided on the carriage and an adjustable dial on the screw to show when the work has been ground to the required diameter.

Extension Tap Holders: Allen Mfg. Co., Hartford, Conn. Extension bars which can be used in connection with taps of standard lengths to do away with the necessity of making up special taps for work where exceptional length is necessary. The extension bar has a socket at one end which receives the squared end of the tap, and is squared at the opposite end to fit the tap wrench.

Portable Electric Drill: Neil & Smith Electric Tool Co., Cincinnati, Ohio. The outstanding features of this tool are strength of construction and simplicity of design. The motor is of the universal type, i. e., it will run on either alternating or direct current without showing a perceptible change of speed. The tool has a capacity for driving drills up to ½ inch in diameter, and weighs 14 pounds.

Shell Grooving, Waving and Undercutting Machine: Jenckes Machine Co., Ltd., Sherbrooke, Quebec, Canada. This machine is adapted for cutting the band seats on 4.5- and 5-inch shells. The work is held in an air-operated collet chuck, and the drive is transmitted through cut gearing. The machine is equipped with a single friction clutch pulley which may be belted direct to the lineshaft.

Universal Sawing Machine: Newton Machine Tool Works, Inc., Philadelphia, Pa. A universal cold saw cutting-off ma-

chine particularly adapted for use in shops engaged in bridge and other structural steel work. The machine is equipped with a compound table which may be swiveled for performing various angular cutting and milling operations, and it is an easy matter to relocate the table in the zero position when square cuts are to be made.

Heat-treating Furnaces: Bellevue Furnace Co., Detroit, Mich. Four types of heat-treating furnaces, one of which is a gas heated furnace for high-speed steel, which is provided with a pre-heating oven. The second and third outfits are cyanide furnaces heated by gas or oil and provided with pre-heating ovens. The fourth is a combination outfit consisting of a gas or oil heated oven furnace, a cyanide bath and a lead bath.

Die Filing Machine: W. D. Rearwin, 341 Mill Ave., Grand Rapids, Mich. This die filing machine is provided with a universal adjustment, and the machine takes files from 12 inches rough down to "needle fine." The file is released from the work on the up-stroke, and the length of the stroke may be adjusted from zero to 7 inches. The table is 17 by 18 inches, and it may be tilted through any angle up to 7 degrees in either direction.

Collapsible Tap: Murchey Machine & Tool Co., Detroit, Mich. This tap has been especially developed for the performance of tapping operations on shrapnel and high-explosive shells. There are two sets of chasers 4.888 and 5.083 inches in diameter, each of which has 11 threads per inch. Both sets of chasers are equipped with a collapsing mechanism which is the same as that employed on standard collapsible taps made by this company.

Thread Miller: Automatic Machine Co., Bridgeport, Conn. A 3-inch internal thread milling machine in which the spindle is advanced to the work by means of a lead-screw which has the same pitch as that which it is desired to produce on the work. The lead-screw is a shell which is fastened to the exterior of the spindle at the rear of the main bearing and its lead is transmitted directly through the lead-nut without gearing. The weight of the machine is approximately 945 pounds.

Cartridge Case Heading Press: Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio. A press designed for use in heading brass cartridge cases after they have been indented. The heading operation is accomplished by inserting a fullering block between the head of the press and the top of the cartridge case which is held in a suitable die. As the pressure is applied, the fullering block causes the brass to flow outward in all directions and forms the head on the case.

Roll Grinding Machine: Norton Grinding Co., Worcester, Mass. An exceptionally large grinding machine constructed for the Carnegie Steel Co. for use in roll grinding. This machine weighs 50 tons and has a capacity for grinding rolls up to 21 feet in length by 50 inches in diameter. The rolls can be swung on centers or supported on their necks, and the machine is capable of removing from 2 to 4½ cubic inches of metal per minute when using wheels 24 inches in diameter by 8 inches face width.

Shell Turning and Boring Machines: Amalgamated Machinery Corp., Chicago, Ill. These are single-purpose machines especially adapted for use in the manufacture of heavy shells. The turning machine has a range for shells from 4.5 to 12 inches in diameter. The range of feeds is from 0.026 to 0.200 inch, and the carriage is provided with quick return and automatic stops. The boring machine is of somewhat similar construction. Both hand and power feed are provided and the hand feed may be used either to accelerate or retard the power feed. The range of power feeds is from 0.006 to 0.200 inch.

Combination Miller and Shaper: Grayson Tool & Mfg. Co., Indianapolis, Ind. A combination machine which differs considerably from other machines for the performance of those classes of work for which the present tool is adapted. The machine is not only adapted for cutting in either direction when used as a vertical shaper or slotter, but it is also provided with vertical and horizontal milling spindles which may be used for drilling, boring or cherrying operations, in addition to regular milling. The machine is particularly suitable for use in the tool-room for working on dies, gages and fine tools of numerous kinds.

Engine Lathe: Dalton Machine Co., 1911 Park Ave., New York City. A single back-geared lathe designed to meet the requirements of general machine shop work. This is nominally a 14-inch machine, but it has an actual swing of 16¼ inches over the ways and 8 inches over the carriage. The cross-slide has a travel of 10 inches and the maximum distance between centers is 36 inches. The range of threads which can be cut is from 3 to 40 per inch, including 11½ per inch. The travel of the tailstock spindle is 5 inches, and the ratio of the back-gears is 7 to 1. The maximum weight of the machine with a six-foot bed is 1850 pounds.

QUOTATIONS OF WHOLESALE METAL PRICES

Week Ending December 24

Aluminum, pig, per pound, ton lots	$ 0.60
Antimony, Asiatic, per pound	0.39
Black sheets, No. 28, per 100 pounds, Pittsburg	2.50
Copper, electrolytic, per pound	0.21
Copper, lake, per pound, New York	0.21
Galvanized sheets, No. 28, per 100 pounds, Pittsburg	4.75
Iron bars, refined, per 100 pounds, Pittsburg	1.90
Iron, pig, foundry No. 2, per ton, Philadelphia	19.00
Iron, pig, basic, valley, furnace, per ton	18.00
Iron, pig, Bessemer, per ton, Pittsburg	19.95
Iron, pig, gray forge, per ton, Pittsburg	18.10
Lead, per pound, New York	0.05½
Nails, cut, per 100 pounds, Pittsburg	1.90
Nails, steel wire, per 100 pounds, Pittsburg	2.00
Spelter, per pound, New York	0.17½
Steel angles, per 100 pounds, Pittsburg	1.70
Steel bars, per 100 pounds, Pittsburg	1.80
Steel beams, per 100 pounds, Pittsburg	1.70
Steel billets, forging, per ton, Pittsburg	52.00
Steel rails, per pound, at mill	0.01¼
Steel tank plates, per 100 pounds, Pittsburg	2.25
Tin, per pound, New York	0.38½
Tin plate, per 100-pound box, New York	3.74
Wire, barbed, galvanized, per 100 pounds, Pittsburg	2.85

The urgent demand for metals continues, and prices are generally higher. Quotations are variable and unreliable as a general index of prices obtained. Pig iron of all grades will be quoted at $20 a ton by January 1, probably. Steel billets have advanced $2 a ton; sheet and tin plate stock at recent sales brought $31 for billets and $32 for bars. Prices as high as $40 a ton have been quoted for rerolling billets. Forging billets are selling as high as $55 a ton. While steel bars are nominally quoted at $1.80, no sales are being made below $2. Bar iron is maintained at $1.90. Wire mills are sold six months ahead and pig iron is being bought for the latter half of 1916. An indication of the profound effect of the war on metal prices is in the price of platinum. While this is a precious metal, it is used to such an extent in the chemical industry in the manufacture of acids required for explosives as to be indispensable. A few months ago, platinum was selling at about $40 an ounce. It now commands $100 an ounce, but is practically unobtainable at any price because of the embargo laid on its exportation by the Russian, French and German governments.

* * *

CORRECTION—"MAKING SLUSH CASTINGS"

An error appears in the statement of allowable impurities in high-grade spelter and the intermediate grade of spelter on page 378 of this number. The paragraphs should read as follows:

High-grade spelter shall contain not over 0.05 per cent cadmium, 0.07 per cent lead, and 0.03 per cent iron, and the sum of these impurities shall not exceed 0.10 per cent.

The intermediate grade of spelter shall contain not over 0.5 per cent cadmium, 0.2 per cent lead, and 0.03 per cent iron, and the sum of these impurities shall not exceed 0.5.

* * *

STEAM RAILWAY STATISTICS FOR YEAR ENDING JUNE 30, 1914

The Interstate Commerce Commission's report for the year ending June 30, 1914, covers 247,397.59 miles of line operated, including 11,298.88 miles used under trackage rights; the aggregate mileage was 377,102.45 miles, of which 247,397.59 miles were classified as single track, 27,604.12 miles as second track, 2696.03 as third track and 2071.45 as fourth, fifth and sixth tracks; 97,333.26 miles were yard tracks and sidings. The increase over 1913 in the aggregate length of all tracks was 7522.65 miles. There were 64,760 locomotives in service, an increase of 1382 over the number for the preceding year. Of the total number of locomotives, 14,612 were classified as passenger, 38,752 as freight, 10,081 as switching, and 1315 were unclassified. The total number of cars of all classes in the service was 2,503,822, as follows: Passenger service, 53,466 cars; freight service, 2,325,647; company's service, 124,709. The total number of persons on the pay-rolls was 1,695,483, a decrease of 119,756 from the number employed in the preceding year. The total amount of wages and salaries paid was $1,373,422.472. The total revenue was $3,047,019,908 and the total operating expenses were $2,200,313,159.

NEWARK WORM-WHEEL SEGMENT HOBBING MACHINE

Two worm-wheel segments are used in the carriages of United States howitzers for the purpose of elevating the gun. In the smaller sizes these are one-piece steel castings containing a hobbed worm-wheel sector which meshes with a Hindley worm. The development of means for hobbing these segments automatically presented some unusual features, but the problem has been worked out very successfully by the Newark Gear Cutting Machine Co., 69 Prospect St., Newark, N. J. The machine employed is a special form of this firm's No. 5 automatic spur gear cutting machine, shown in Fig. 1, the capacity of which has been increased to swing work up to 96 inches in diameter as compared with a swing of 60 inches on the standard machine. The modifications of the design also provide additional travel for the work-head, and the special machine is capable of cutting worm-wheels or worm-wheel segments in addition to spur gears. The cutting of spur gears and worm-wheels is really incidental to the use of the machine for automatically hobbing interrupted worm-wheel segments or those which cannot be cut economically by completely revolving the work.

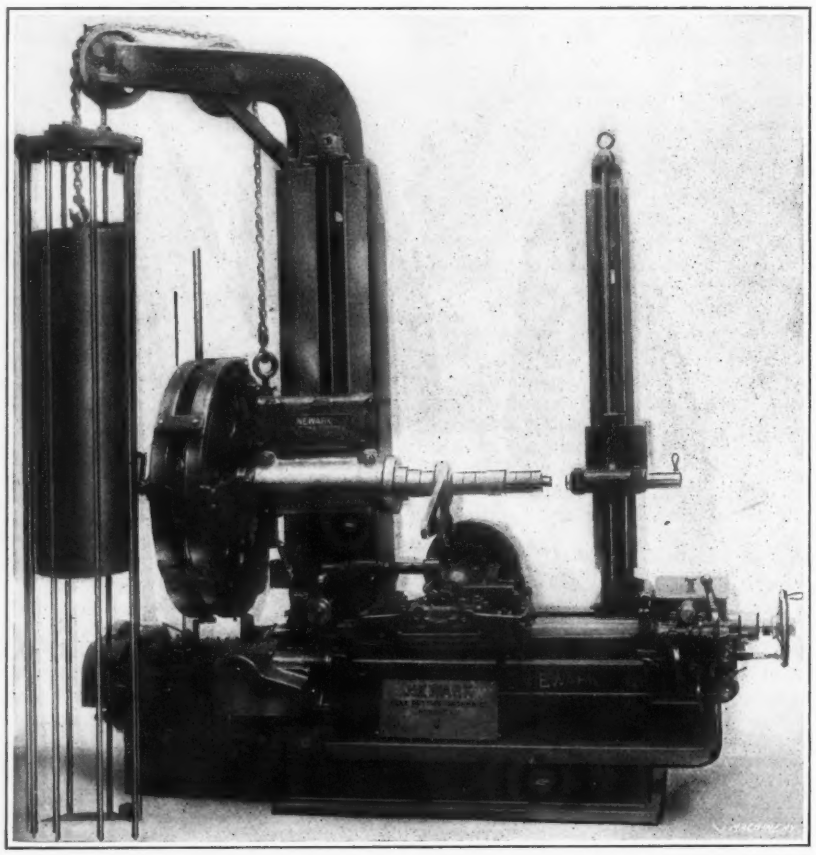


Fig. 1. Newark No. 5 Gear-cutting Machine adapted for hobbing Worm-wheel Segments

An example of such a worm-wheel segment is shown at *A* in Fig. 2, and this is the class of work for which the machine was especially designed. This form of segment is cut entirely automatically by gearing the work-spindle in unison with the cutter-spindle, revolving the hob through its cutting movement until the small gap at the end of the worm-wheel teeth is reached, then lifting the work away from the hob, and reversing and returning it to the free end of the segment, at which point it is lowered and once more engaged by the hob. Each time the work is lowered it descends a little further than on the previous downward movement, and this feeding motion is continued until the correct center distance is reached, at which point an automatic stop disengages the feed. An earlier model of one of these machines has been in use for several years; during a part of this time it has been employed on night work, and it is stated that the machine has always performed its functions correctly.

It was mentioned that the machine is capable of cutting spur gears and worm-wheels in addition to worm-wheel segments. When engaged in cutting spur gears, the work-spindle head is raised or lowered by power to bring it to the proper position on the column, where it is rigidly secured. For this work, a rotary gear cutter is used in place of a hob, and this cutter is fed through the work and then returned rapidly, after which the work is positively indexed to bring it into position for cutting the next tooth space. This operation is the same as that of the standard No. 5 gear cutting machine of which this is a special type. When the machine is employed for cutting full circle worm-wheels, the work-head is set free to move on the column, the cutter-head is locked in such a position that the hob is located at the center of the worm-wheel face, and the feed and return clutches are locked in their neutral positions. The gearing is engaged to connect the cutter and work arbor drives in the proper ratio for the worm-wheel to be cut, and the feed mechanism for the work-head is brought into action.

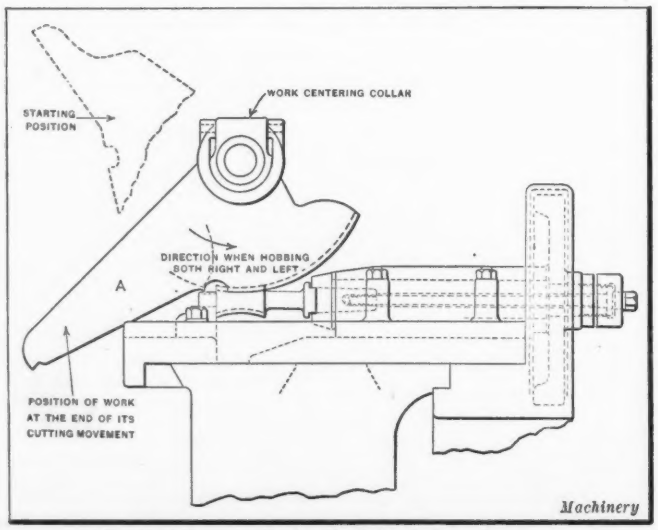

WORK CENTERING COLLAR
STARTING POSITION
DIRECTION WHEN HOBBING BOTH RIGHT AND LEFT
A
POSITION OF WORK AT THE END OF ITS CUTTING MOVEMENT
Machinery

Fig. 2. Diagram showing Method of Operation on a Worm-wheel Segment

When the machine is engaged in cutting worm-wheel segments, in addition to the movements described for use in the cutting of worm-wheels, a positive work-head raising clutch is connected and the mechanism is engaged for breaking and making connection with the worm-wheel ratio gearing, as well as for reversing this gearing. All power is taken from the constant-speed shaft *A*, Fig. 3, and the drive is transmitted to the cutter through bevel gears which make connection with shaft *B*. Shaft *C* is geared so that its speed is a multiple of the cutter-spindle speed, and this shaft transmits power to the ratio drive reversing clutches *D*, *E*, and *F*. Clutch members *D* and *E* revolve in opposite directions. The ratio drive is carried on through change-gears *G*, *H*, and *I* to the master worm and wheel from which it is transmitted to the work-spindle.

From shaft *B* power is transmitted through gears *J*, *K*, and *L* to shaft *M*, and then through gears *N* and *O* and shaft *P* to gears *Q* and *R*. Gear *R*, in turn, drives clutch member *S*, and when clutch *T* is thus revolved it drives gears *U* and *V* and shaft *W*, from which the power is transmitted to gears *X* and *Y*. The ratio is such that gear *V* makes one revolution to each half revolution of gear *Y*, and this gear *Y* carries a crankpin *Z* which acts in conjunction with link *a* to transmit motion to a second crankpin *b* and gears *c* and *d*. Through shaft *e* power is transmitted to the double stud *f* which

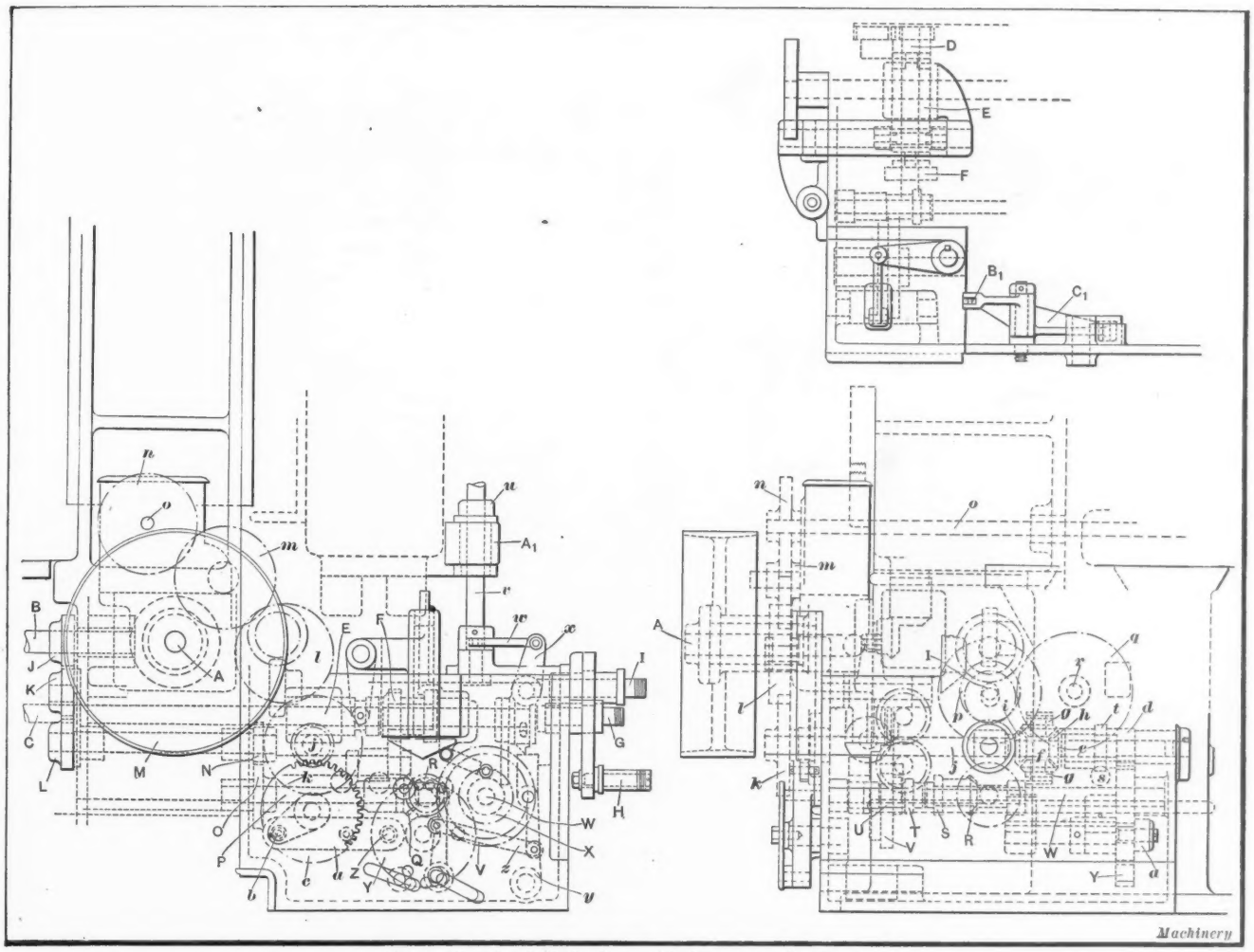


Fig. 3. Details of Mechanism on Machine shown in Fig. 1

carries bevel gears g that engage bevel gear h. In this way the motion is transmitted to bevel gear i, then through shaft j and gears k, l, m, and n to shaft o, whence it is transmitted through bevel gears to the head raising screw, which is not shown.

A small amount of power is by-passed from ratio gear-shaft I through gears p and q to shaft r, which carries a crank-disk operating a pawl that revolves a ratchet wheel on worm-shaft s. From this point the motion is carried on to worm-wheel t, which is secured to bevel gear h, and also acts on the head raising screw. A large ring, which is not shown in the illustration, is mounted on the work-spindle and carries two adjustable dogs that engage lever u, causing shaft v to oscillate. Through link w, levers x and y and link z, engagement is made with clutch members T and S, thus operating the raising and lowering mechanism for the work-head. The feeding train containing the worm-wheel t is stopped by an arm on lever bearing A_1, which engages an adjustable dog on rod B_1, raising the ratchet pawl through engagement with lever C_1.

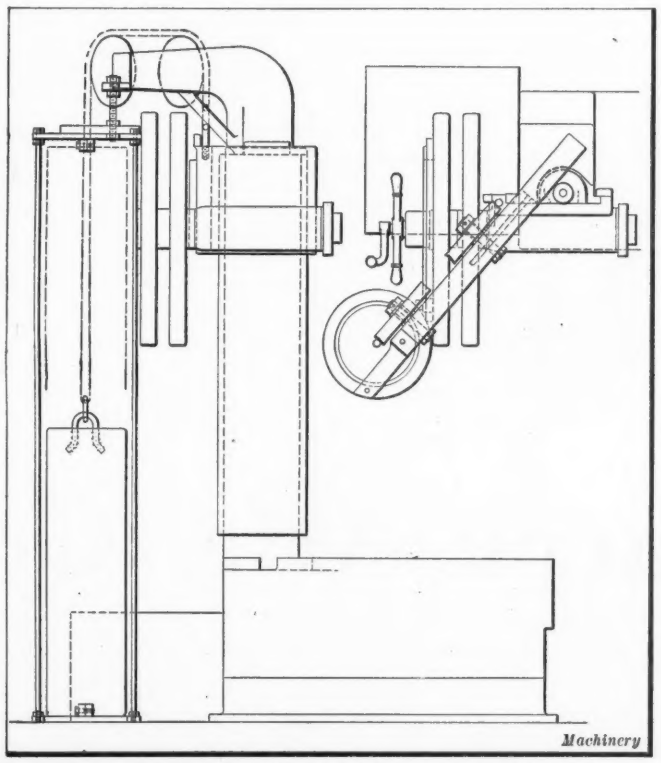


Fig. 4. Arrangement of Counterweight for Work-spindle Head

The raising and lowering gear train simultaneously operates the sliding clutch member E, which results in reversing the ratio train. To insure correct engagement of the ratio train so that the hob will always catch the right tooth, clutch

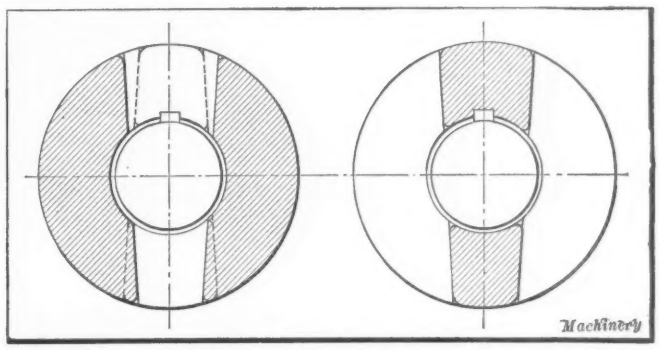
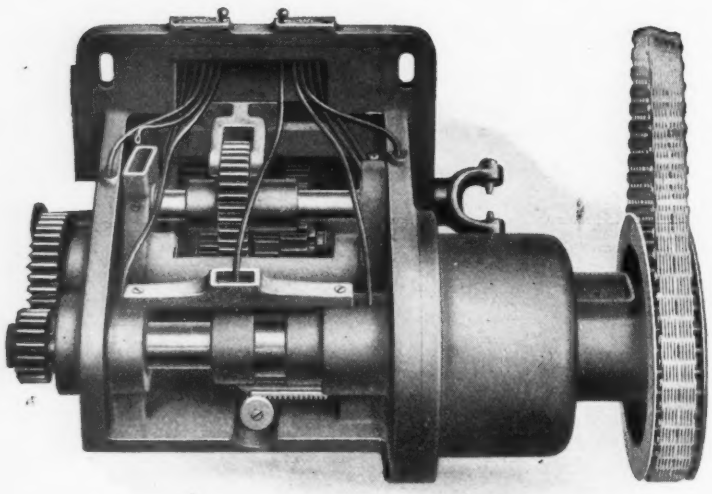
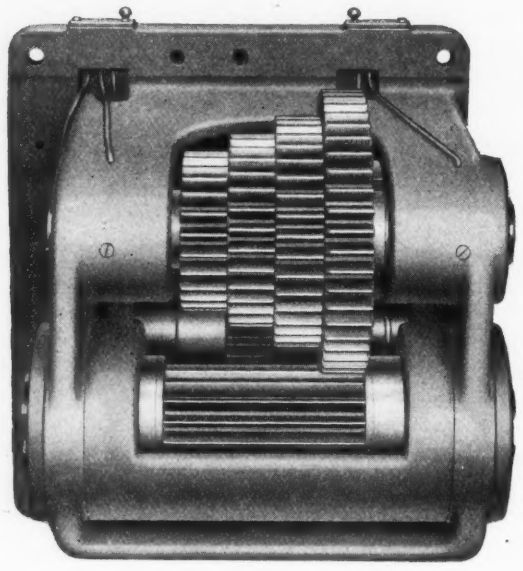


Fig. 5. Form of Clutch employed to insure having Hob always catch the Right Tooth

members D, E, and F are made with two teeth of different widths, the arrangement being shown in detail in Fig. 5, so that they can only be engaged when the large tooth is opposite the large space. The purpose of employing two teeth was to provide for easier disengagement of the clutches under strain. As the driving clutch members are geared so that their speed is a multiple of the hob spindle speed, they always



WHEN you contemplate the purchase of a machine you take unusual care in comparing its specifications with your requirements—you endeavor to make sure that the machine will perform the work you have for it. But in checking up its features, how much attention do you give to one of the most important construction points—bearings?



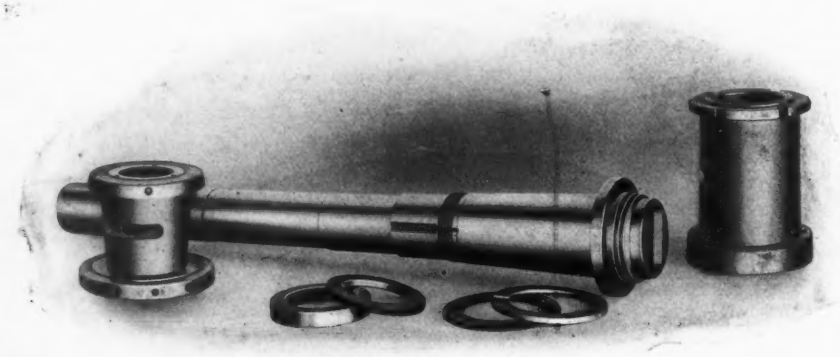
Bearings

are vital parts of all machinery. The life and efficiency of the machine depend largely upon the quality of the bearings, but, being out of sight, they are often hastily considered.

Quality in bearings is hard to determine on mere examination. Time and service are the elements that prove their real worth. Bearings may look alike but constant service soon shows up inferior work to the detriment of the machine and its productive capacity.

The size, distribution and support of bearings on Brown & Sharpe machines are points that receive special consideration in design and manufacture. Take our milling machines as typical instances. The cuts on this page show characteristic examples of the way bearings are arranged and finished.

Notice how the heavy shafts are mounted in long bearings firmly supported in massive housings. The principal shafts are hardened and ground and run in bronze boxes and each shaft is solidly supported close to the point of pressure.

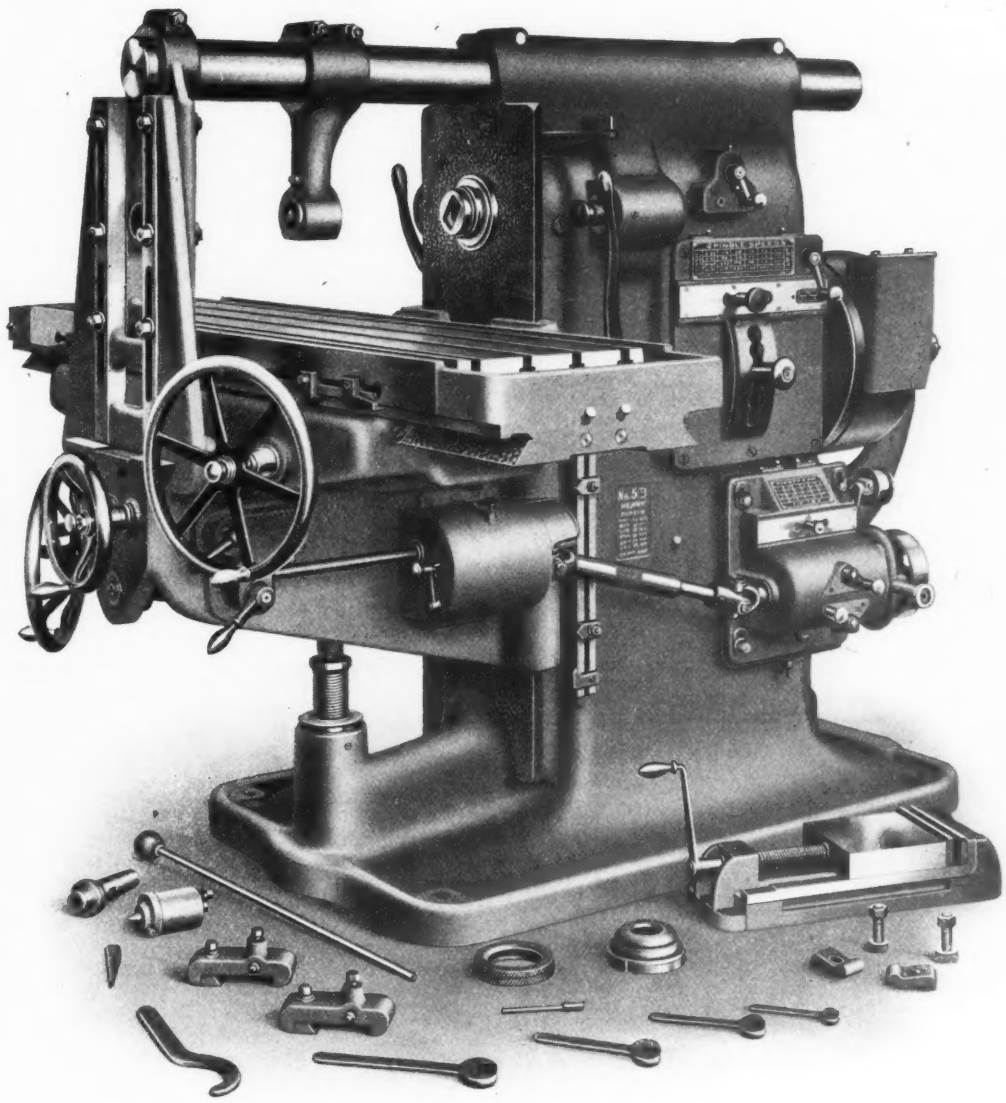


Flat surfaces are carefully scraped. High-grade work, extreme care and rigid inspection combine to produce true, accurately aligned bearings that remain in first-class condition through years of service.

Brown & Sharpe Mfg. Co., P

OFFICES: 20 Vesey St., New York, N. Y.; 654 The Bourse, Philadelphia, Pa.; 626-630 Washington Blvd., Chicago, Ill.; 305 Chamber of Commerce Bldg., Rochester, N. Y.; Room 419, University Block, Syracuse, N. Y.

REPRESENTATIVES: Baird Machinery Co., Pittsburgh, Pa., Erie, Pa.; Carey Machinery & Supply Co., Baltimore, Md.; E. A. Kinsey Co., Cincinnati, O., Indianapolis, Ind.; Pacific Tool & Supply Co., San Francisco, Cal.; Strong, Carlisle & Hammond Co., Cleveland, O., Detroit, Mich.; Colcord-Wright Machinery & Supply Co., St. Louis, Mo.; Perine Machinery Co., Seattle, Wash.; Portland Machinery Co., Portland, Ore.



Brown & Sharpe Heavy Service Plain Milling Machines

in addition to having true, carefully finished bearings, have the sturdiness in design to give them adequate support and prevent them from sagging out of alignment under stresses. The No. 5-B Heavy Plain Machine shown above is characteristic of our line of heavy service milling machines in this respect.

Take careful note of the massive proportions of this frame and the liberal size of the knee saddle and table. Observe the width of the column and the length of the bearing it gives the knee. There is no sagging or warping under heavy loads with construction like that. And the machine is consistent throughout. Every part is proportionately strong and well supported—all designed with these ends in view—heavy service—accurate work—fast production—long life.

We shall be glad to tell you more about this machine. Descriptive literature free on request.

Providence, R. I., U. S. A.

CANADIAN AGENTS: The Canadian Fairbanks-Morse Co., Ltd., Montreal, Toronto, Winnipeg, Calgary, Vancouver, St. Johns, Saskatoon.

FOREIGN AGENTS: Buck & Hickman, Ltd., London, Birmingham, Manchester, Sheffield, Glasgow. F. G. Kretschmer & Co., Frankfort a.M., Germany; V. Lowener, Copenhagen, Denmark, Stockholm, Sweden, Christiania, Norway; Schuchardt & Schutte, Petrograd, Russia; Fenwick, Freres & Co., Paris, France; Liege, Belgium; Turin, Italy; Zurich, Switzerland; Barcelona, Spain; The F. W. Horne Co., Tokio, Japan; L. A. Vail, Melbourne, Australia; F. L. Strong, Manila, P. I.

READ PAGE 67

engage at the same point on the hob. Two master worm-wheels are provided, the inner one for use in accurate spur gear cutting and the outer one for intermittent worm-wheel work. The reason for providing two worm-wheels in this way was because it was thought advisable to provide against errors due to excessive wear in those sections of the worm-wheel which receive the greatest amount of service in cutting worm-wheel segments. The successful operation of the machine is in a great measure due to the counterbalancing of the work-head, as shown in Fig. 4. To counteract the unbalanced pull of the weight on the column, a screw and jam nuts of generous proportions are provided so that the cage surrounding the weight takes the direct strain of the weight and thus increases the stability of the machine as a whole.

* * *

SECRECY VS. ORIGINALITY

One of the reasons for not receiving visitors in manufacturing plants, seldom admitted, is the fear that the visitors may recognize methods and designs stolen bodily from competitors. The usual plea for maintaining a shop closed to visitors is that valuable methods have been developed at great expense and trouble, and that no competitor should be given knowledge of them, either directly or indirectly! An instance illustrating the inconsistency of some such concerns came to our attention not long ago. A concern had accorded the privilege of publishing a description of certain methods developed in its plant, and the article duly appeared; whereupon a competitor raised a dreadful howl because of alleged discrimination. As a matter of fact the "howler" had refused to permit a description of a development in use in his plant—and in several other manufacturing plants—to be published. He dared not claim credit for it. For such cases there is little hope in this world, because the individuals concerned having little or no originality cannot display to the public the generosity necessary to obtain for themselves the recognition they so greatly crave.

* * *

AN EXAMPLE OF SPECIALIZATION

The superintendent of an automobile factory in Indiana was interviewing an applicant for a job.

"Have you ever had any experience on automobile work before?"

"Sure! I worked for the Ford Motor Co. for three years."

"That sounds good. You ought to know something about automobiles then. What department did you work in?"

"The assembling department."

"Well that's all right, but tell me something about the work you did."

"Oh, I gave nut No. 16 two turns on its stud."

* * *

PERSONALS

Thomas F. Fournier, chief engineer of the Becker Milling Machine Co., Hyde Park, Boston, Mass., has resigned the position to become general manager of the Standard Machinery Co., Mystic, Conn.

Albert Vuilleumier, assistant chief engineer of the Becker Milling Machine Co., Hyde Park, Boston, Mass., has resigned the position to become works manager of the Standard Machinery Co., Mystic, Conn.

John Lynch, formerly of the Baird Machine Co., Bridgeport, Conn., has been made superintendent of the Blake & Johnson Co.'s plant in Waterville, near Waterbury, Conn., succeeding Louis A. Crittsinger, resigned.

Edgar W. Cleveland, for some time employed by the National Automatic Tool Co., Richmond, Ind., as mechanical engineer, has returned to his former position in the designing department of the Fox Machine Co., Grand Rapids, Mich.

John W. Bryce, for the past four years superintendent of the steel ball department of the New Departure Mfg. Co., Bristol, Conn., has resigned his position to become general superintendent of the Abbott Ball Co., Elmwood, Conn.

B. W. Burtsell, assistant factory manager of the Packard Motor Car Co., Detroit, Mich., and formerly of the Brown & Sharpe Mfg. Co., Providence, R. I., has taken a position as sales manager with the Whitney Mfg. Co., Hartford, Conn. Mr. Burtsell will be assisted by W. W. Totman and H. L. Sevin.

Charles A. Odegaard, for the last seven years connected with the Marshall & Huschart Machinery Co., Chicago, Ill., as salesman and correspondent, has joined the Federal Machinery Sales Co., 12 N. Jefferson St., Chicago, as secretary. James Jay Sheridan has resigned his position as secretary but retains his directorship in the company.

Campbell Scott, who for the last eleven years has been manager of the Otis Elevator Co.'s works at Yonkers, N. Y., has resigned his position, taking effect the end of December. Before joining the staff of the Otis Elevator Co., Mr. Scott had, for eight years previous, been associated with the C. & C. Electric & Mfg. Co. of New York, as secretary and general manager.

* * *

OBITUARIES

Thomas J. Hennessey, formerly division master mechanic on the Michigan Central Railroad, died December 4, aged seventy years. Mr. Hennessey was retired from service on account of age limit, February 1, 1915.

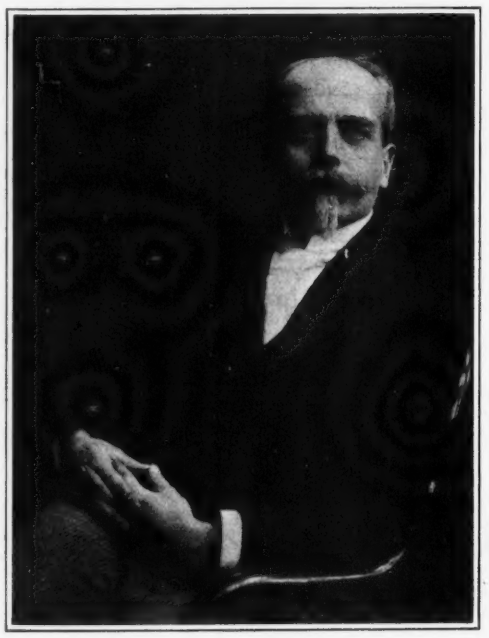
Joseph Fahys, reputed to be one of the first watchcase manufacturers in America, died December 11, at his home in Sag Harbor, Long Island, aged eighty-three years. He was president of Joseph Fahys & Co., New York City.

H. J. Bierhart, superintendent of C. C. Bradley & Son, Syracuse, N. Y., makers of power hammers, died at his home in Syracuse, November 25, after a brief illness with pneumonia, aged seventy-one years. Mr. Bierhart left a widow, three daughters and a son, Henry J. Bierhart, Jr., who is with the die-casting division of the H. H. Franklin Mfg. Co., Syracuse.

George Nash, former president of the George Nash Co., died at his home in New York, November 29. Mr. Nash was born in England and was educated abroad, but came to America when a very young man. After acquiring some business experience in New York City he entered the employ of Carl Boker, importer of steel, and founder of Hermann Boker & Co., with whom he gained a very wide knowledge of the steel business. In 1890 Mr. Nash started in business for himself in Chicago, and subsequently formed a partnership with Edgar T. Ward of Boston, also a steel importer, under the name of Ward & Nash. The firm kept stocks of steel in both Boston and Chicago. In 1900 this partnership was dissolved, and Mr. Nash established the steel importing house of George Nash & Co., with warehouses in New York and Chicago. In 1906 the corporation of the George Nash Co. was formed, Mr. Nash continuing as its active head as president and treasurer until 1911, when he disposed of most of his interest. After retiring he devoted his time between his winter home at Montclair, N. J. and his summer home at Mallett's Bay, Lake Champlain. Mr. Nash was widely known by the steel trade and the manufacturers of this country.

JAMES MAPES DODGE

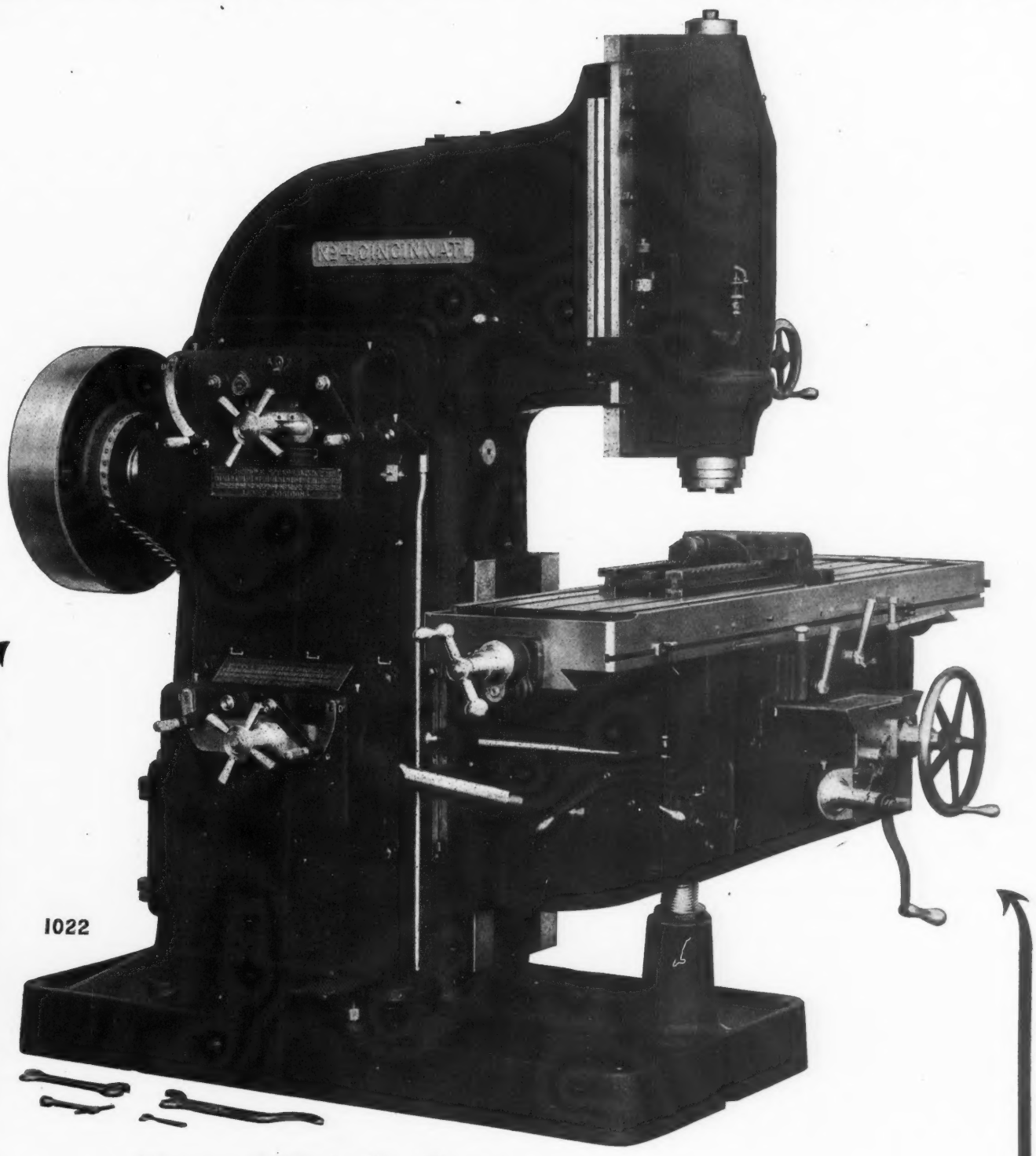
James Mapes Dodge, chairman of the board of the Link-Belt Co., died at his home in Philadelphia, December 4, aged sixty-



James Mapes Dodge

three years. He was born at Waverly, N. J. His grandfather was Prof. James J. Mapes, a noted chemist and scientist,

CINCINNATI VERTICALS



Unusual Spindle Power.
Heat Treated Alloy Steel Hardened Gearing.
Massive Spindle Head Construction.
Handy—Can mill around a rectangle without stopping feed or speed.

These are some reasons why you should use Cincinnati Verticals

THE CINCINNATI MILLING MACHINE CO.
CINCINNATI, OHIO

and his mother, Mary Mapes Dodge, was a well-known author, for many years editor of the *St. Nicholas Magazine*. Mr. Dodge spent three years at Cornell University and a year at Rutgers, taking a course in chemistry at the latter institution. After working a short time at the Morgan Iron Works in New York City, he entered the shops of John Roach, the shipbuilder, at Chester, Pa., where his marked mechanical ability and ingenuity brought him rapid advancement. During the three years spent at the Chester establishment, he was successively journeyman, foreman and superintendent of erection.

Shortly after the Centennial Exposition at Philadelphia in 1876, Mr. Dodge left the shipyard, and after gaining several years of experience in the East, went to Chicago. It was there that he formed the acquaintance of William D. Ewart, the inventor of the Ewart link-belting, and soon after he joined with Mr. Ewart and his associates in the development of the chain business. At that time—about thirty-five years ago—the application of chains to power transmission was limited, and their use in elevating and conveying machinery was practically unknown. The development of the Ewart chain made a new industry, and Mr. Dodge's early work was confined principally to the development and manufacture of Ewart chains, in which work his genius had full play. New chains, new methods of manufacture and new conveying and elevating appliances were brought out in rapid succession.

After this period of development, Mr. Dodge went East and entered into partnership with Edward H. Burr under the firm name of Burr & Dodge, who represented in Philadelphia the Ewart Mfg. Co. of Indianapolis, the original manufacturer of Ewart detachable link-belting. Out of this partnership grew the Link-Belt Engineering Co. in 1888, and after the formation of this company, Mr. Dodge carried out his idea of development along strictly engineering lines. A highly specialized engineering staff was organized; a scientific study was made of the characteristics of the materials to be handled, and special appliances were invented to meet varying conditions. Machine capacities grew from 30 tons per hour to 1000 tons per hour, and from the simple problems solved by detached machines the company expanded its field to the planning and arranging of works to secure the most economical and efficient handling of both raw and finished product under guarantee of accomplishment. In all this development, Mr. Dodge was the creative and guiding spirit.

It was in 1889, after having become thoroughly acquainted with the needs of the anthracite coal industry, that Mr. Dodge developed the boldest and perhaps the most original of his inventions. This was his system of storing anthracite coal in large conical piles, and reloading it by machinery, accomplishing this result with little labor and practically no breakage. For this meritorious invention, Mr. Dodge was presented with the Elliott Cresson gold medal in 1907 by the Franklin Institute of Philadelphia. This system of handling coal in and out of storage reduced the cost from thirty and often forty cents per ton to less than five cents. Mr. Dodge had the distinction of having taken up over 100 patents. Among his most important inventions and improvements are those relating to the construction and manufacture of the "silent chain."

Though for many years an employer of labor, Mr. Dodge never met with strikes or other labor difficulties. He was a conspicuous leader in the general introduction of the best elements in scientific management, having the double purpose of producing greater efficiency in the mechanical and human equipment and greater pay with shorter hours and improved conditions for the men. He was for many years closely associated with the late Frederick W. Taylor in the accomplishment of remarkable results for the benefit of both employers and employes in a wide circle of industries. He was a member of several engineering and scientific bodies; he was past president of the American Society of Mechanical Engineers, and vice-president of the Franklin Institute.

COMING EVENTS

January 1-8.—National automobile show, Grand Central Palace, New York City. S. A. Miles, general manager, 7 E. 42nd St., New York City.

January 5-6.—Annual mid-winter meeting of the Society of Automobile Engineers. Grand Central Palace, New York City, headquarters. Coker F. Clarkson, general manager, 1776 Broadway, New York City.

January 27-29.—National foreign trade convention, at New Orleans, La., for the discussion of commercial relations of the United States with foreign countries. Hotel Grunewald, headquarters. James A. Farrell, chairman, 64 Stone St., New York City.

September 11-16.—Annual convention of the American Foundrymen's Association and the American Institute of Metals, Cleveland, Ohio, in the Cleveland Coliseum. A. O. Backert, secretary-treasurer, American Foundrymen's Association, Cleveland, Ohio.

SOCIETIES, SCHOOLS AND COLLEGES

Massachusetts Institute of Technology, Boston, Mass. Bulletin of the Institute containing catalogue of officers and students, with a statement of the requirements for admission and description of the courses of instruction.

University of Illinois, Urbana, Ill., has maintained since 1907 ten research fellowships in the Engineering Experiment Station. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. By action of the board of trustees last March, four additional research fellowships were created, making fourteen in all. There will be five vacancies to be filled at the close of the current academic year. Research work may be undertaken in architecture, architectural engineering, chemistry, civil engineering, electrical engineering, mechanical engineering, mining engineering, municipal and sanitary engineering, physics, railway engineering, and theoretical and applied mechanics.

NEW BOOKS AND PAMPHLETS

Rockefeller Foundation Annual Report 1913-1914. 226 pages, 5¾ by 8⅝ inches. 17 illustrations. Published by the Rockefeller Foundation, 61 Broadway, New York City.

The Production of Coal in 1914. By C. E. Lesher. 164 pages, 6 by 9 inches. Published by the United States Geological Survey, Department of the Interior, from the "Mineral Resources of the United States, 1914, Part II."

Annual Report of the Secretary of the Navy for the Fiscal Year Ended June 30, 1915, including operations and recommendations to December 1, 1915. 104 pages, 6 by 9 inches. Published by the Department, Washington, D. C.

Characteristics of Radiation Pyrometers. By George K. Burgess and Paul D. Foote. 88 pages, 6 by 10 inches. 32 illustrations. Published by the Department of Commerce, Washington, D. C., as Scientific Paper of the Bureau of Standards No. 250.

Psychrometric Tables for Cooling Tower Work. 56 pages, 4 by 7 inches. Published by the Wheeler Condenser & Engineering Co., Carteret, N. J., for free distribution to engineers.

This booklet of tables gives the dry and wet bulb thermometer readings, dew point, humidity, and the pounds of water vapor per thousand cubic feet and per hundred pounds of air. It contains a discussion of psychrometry and describes the use of the sling psychrometer, which is illustrated.

Steam Tables for Condenser Work. 32 pages, 4 by 7 inches. Illustrated. Published by the Wheeler Condenser & Engineering Co., Carteret, N. J., for free distribution to engineers.

This booklet of steam tables in the third edition includes pressures below atmosphere, expressed in inches of mercury referred to a thirty-inch barometer. It also includes a discussion of the use of the mercury column, points out the errors in such measurements and gives the constants to be used for their correction.

Principles and Practice of Cost Accounting. By Frederick H. Baugh. 194 pages, 6 by 9 inches. Published by F. H. Baugh, Box 682, Baltimore, Md. Price, $3.

This work on cost accounting is intended for accountants, manufacturers, mechanical engineers, teachers and students, having for its object a comprehensive and practical presentation of the general principles on which cost accounting for manufactured articles is based. It deals with financial accounting, principles of cost accounting, specific job costs, departmental costs, process costs of the simple type, process costs of the complex type and gives examples of departmental cost accounts and process costs.

Arithmetic of Electricity. By T. O'Conor Sloane. 162 pages, 5 by 7¼ inches. Published by Norman W. Henley & Co., New York City. Price, $1.

This book now appears in the twenty-first edition, having first been published in 1909. It is a practical work of electrical calculations of all kinds reduced to a series of rules, all of the simplest forms, and embodying only ordinary arithmetic. Each rule is illustrated by one or more practical problems with detailed solution of each. It treats of Ohm's law; resistance and conductance; potential difference; circular mils; special systems; work and energy; batteries; electro-magnets, dynamos and motors; electric railways; alternating currents; condensers, etc.

Notes on the Use of Low-Grade Fuel in Europe. By R. H. Fernald. 37 pages, 6 by 9 inches. Illustrated. Published by the Department of the Interior, Bureau of Mines, Washington, D. C., as Technical Paper 123.

This pamphlet treats of the utilization of high-ash coals in non-by-product producer gas plants; the use of wood refuse and similar material; by-product plants; uses of tar; low-temperature distillation; use of powdered fuel, etc. The investigation was made in the interests of the fuel resources in the United States. While we have an abundant supply of high-grade fuel, the rate at which it is being used leads naturally to the assumption that steps should be taken in the near future to utilize our low-grade fuels also, and thus conserve the national fuel supply.

Autogenous Welding and Cutting. By Theodore Kautny. Translated by the author and James F. Whiteford. 157 pages, 5 by 7½ inches. 133 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $1 net.

This small book deals with autogenous welding flames; acetylene manufacture and apparatus; oxygen manufacture and apparatus; gas mains and fittings; autogenous welding burners; autogenous cutting burners; autogenous welding of iron; repairs of gray cast iron; welding of sheet iron; manufacture and repairs of boilers; manufacture of cylindrical and rectangular vessels and miscellaneous articles; manufacture and installation of large pipes and conduits; manufacture and installation of gas and water pipe; construction of pipe-shaped apparatus; welding of copper; welding of aluminum; welding of nickel and other metals.

Laboratory Tests of a Consolidation Locomotive. By E. C. Schmidt, J. M. Snodgrass and R. B. Keller. 129 pages, 6 by 9 inches. 58 illustrations. Published by the University of Illinois, Urbana, Ill., as Bulletin 82 of the Engineering Experiment Station. Price, 65 cents.

The tests whose results are recorded in this bulletin constitute the first work done in the recently established locomotive laboratory of the University of Illinois, and relate to a typical consolidation locomotive. The locomotive was first tested in the condition in which it was received from service. It was then repaired and again tested. The maximum amount of dry coal fired per hour was 11,127 pounds per square foot of grate per hour. The maximum equivalent evaporation per hour was 57,954 pounds, or 17.65 pounds per square foot of heating surface per hour.

Inventions and Patents. By Philip E. Edelman. 288 pages, 6¼ by 8 inches. Published by the D. Van Nostrand Co., New York City. Price, $1.50 net.

The author, realizing the general ignorance of patent procedure, and the possibilities in patented inventions, has written this book for inventors, investors, manufacturers and others for whom elementary information on the patent system would be acceptable. It treats of the development of the patent system, the patent office, patent attorneys, the fields of invention, preliminary steps required to secure patents, patentability and practicability, how to apply for and prosecute a patent, how to protect an invention, the points of patent procedure, how to secure and utilize patent rights, how to dispose of patent rights, what to do in case of infringements, foreign patents and other matters of general interest.

Eighteen Articles. By J. P. Brophy. 87 pages, 5 by 6¾ inches. Bound in paper. Published by the Cleveland Automatic Machine Co., Cleveland, Ohio.

This little book, by the general manager of the Cleveland Automatic Machine Co., is compiled chiefly from articles contributed by Mr. Brophy to the technical press. The contents are short essays as follows: Interchangeability; Punctuality; Office Management; Value of the Setter-up; The Difference between Designer and Inventor; Management and Responsibility; Efficiency—Its Meaning; Classified Supervision; The Fault Finder; Selecting Foremen and Assigning Their Duties; Inventory—Costs, Depreciation, All Closely Allied; Reflection—Its Definition Elaborated; Defining a Purchasing Agent's Duties; Stock Parts in Advance—Does It Pay?; Making Headway; At What Age are we most Efficient?; Writing an Advertisement; Little Things—and a Place for Everything.

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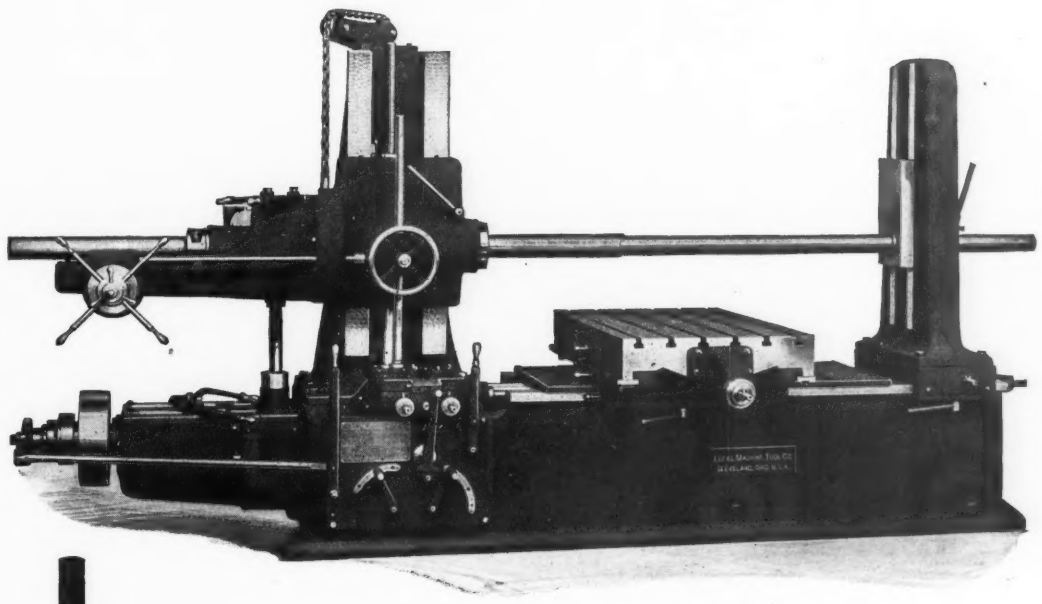

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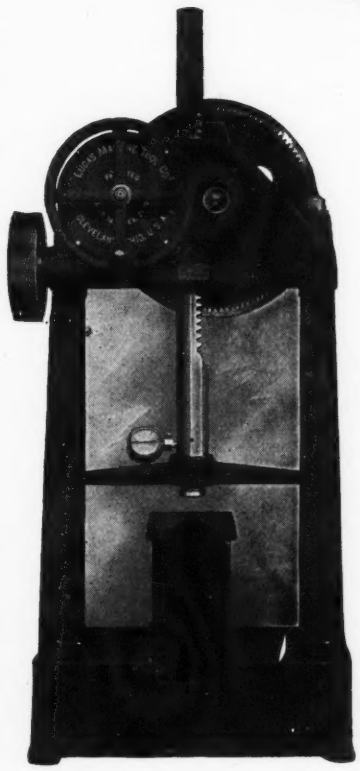

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Engineering Thermodynamics. By James A. Moyer and James P. Calderwood. 203 pages, 6 by 9 inches. 70 illustrations. Published by John Wiley & Sons, Inc., New York City. Price, $2 net.

This work is offered as a textbook on thermodynamics that is brief and concise, and so clearly expressed on the fundamentals of the subject that students of average ability can read and study it without difficulty. It has been the aim of the authors to make the work particularly suitable for use in the larger technical schools where the study of thermodynamics is preceded by courses on steam boilers and steam or heat engines, and where courses on steam turbines, internal combustion engines, pneumatic machinery, refrigeration and pumping machinery are included. Following the introduction to the theory of heat engines, the properties of perfect gases are taken up, and then expansion and compression of gases. In logical order follow the cycles of heat engines, properties of steam, practical applications of thermodynamics, entropy, practical steam expansions and cycles, and flow of fluids.

The Testing of Machine Tools. By George W. Burley. 231 pages, 4½ by 7¼ inches. 110 illustrations. Published by Scott, Greenwood & Son, London, and sold in the United States by D. Van Nostrand Co. Price, $1.50.

The author, a well-known writer on machine tool design and machine shop practice, has dealt in this work with the various aspects of machine tool testing in a way that makes it suitable for the use of apprentices, students and engineers. It deals with tests on machine tool elements for accuracy; machine tool speed and feed tests; machine tool mechanical efficiency tests; cutting force tests; output and power consumption tests; comparative tool testing; and commercial machine tool testing. A chapter describes engine lathe tests, bed leveling tests, spirit levels, spirit level graduations, hydrostatic level, gravity or pendulum level, pendulameter, headstock tests, micrometers, test indicators, driving headstock spindle tests, loose headstock mandrel tests, slide-rest tests, finished lathe tests, wear tests, lead-screw tests, slide screw tests, lathe test report, turret lathe tests, milling machine tests, drilling machine tests, planing machine tests, general observations. The work is one that should be of general value to all concerned with the manufacture and use of machine tools.

Corrosion of Iron. By L. C. Wilson. 178 pages, 5 by 7¼ inches. Published by the Engineering Magazine Co., New York City. Price, $2.

This is an age of iron and steel, but the works of iron and steel are far from being permanent. Perhaps one of the greatest problems confronting the engineer today is that of preserving metal structures from the deteriorating influences of wind and water. The author's purpose has been to assemble and condense the most interesting and important studies and facts connected with the corrosion of iron and its protection therefrom. After dealing with the rust problem, he takes up the theories of corrosion. Three principal theories are discussed, these being the hydrogen peroxide theory, the carbonic acid theory and the electrolytic theory. Protective measures then receive attention. These include oxidizing, galvanizing, electroplating and painting. Paint materials are dealt with in Chapter IV and protective paints in Chapter V. Following the discussion of protective paints, the influences of different elements on the corrosion of iron are taken up, and then corrosion of wrought-iron and steel pipe. So serious is the deterioration of steel pipe that iron pipe is being used largely in preference because of its superior rust-resisting characteristics.

Smoke Abatement and Electrification of Railway Terminals. 1177 pages, 9 by 12 inches. 719 illustrations. Supplied by Rand McNally & Co., Chicago, Ill. Price, $6.

This comprehensive report of the Chicago Association of Commerce Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals—Dr. W. F. M. Goss, chief engineer—is a notable contribution to the literature of engineering. The physical characteristics of the city of Chicago are described and the work of smoke abatement in foreign and American cities. The work is divided into four parts and an appendix, as follows: The Necessity for the Electrification of Chicago's Railroad Terminals; Technical Feasibility and Cost of Electrifying the Railroad Terminals of Chicago; A Study of Results which are to be Anticipated from the Electrification in Chicago; Financial Practicability of Electrification; Summary of Conclusions with Reference to the Electrification of Railroad Terminals; Summary of Conclusions with Reference to Atmospheric Pollution. An idea of the amount of statistical matter can be gathered from the fact that 478 tables accompany the text. The work has been prepared with great care; it is logically arranged and thoroughly indexed so that any subject can be quickly referred to.

Steel and its Treatment. By the Metallurgical Staff, E. F. Houghton & Co. 104 pages, 5¼ by 7½ inches. 24 illustrations. Published by E. F. Houghton & Co., Philadelphia, Pa.

The company publishing this book has for over forty years been engaged in the manufacture of materials used in the heat-treatment of steel and during that time it has conducted a laboratory of research. During the last fifteen years the development of the heat-treatment of steel has led to the collection of data which is now published in convenient form. The work deals with the composition of steel; the thermal critical points of steel; annealing; methods of testing the hardness of metals; Turner's sclerometer; Shore's scleroscope; Brinell's tests; Keep's test; pyrometers; carbon steels; low carbon steels; thermal critical points of a medium high carbon steel, eutectoid steel and hyper-eutectoid steel; influence of carbon, manganese, phosphorus, sulphur, silicon, nickel, chromium and vanadium; thermal- or heat-treatment of steel; hardening of steel; tempering or drawing; carburizing; composition of steels for carburizing, carburizing temperatures; depth of penetration; casehardening, carburizing compounds; heat-treatment after carburizing; composition of the metal; quenching; special alloys; nickel steels; nickel-chromium steels, etc.

Safety in the Foundry. By Magnus W. Alexander. 187 pages, 5¼ by 7¼ inches. 140 illustrations. Published by the National Founders' Association, Chicago, Ill. Price, $1.25 to members of the association, and $1.50 to others.

This book by Mr. Alexander of the General Electric Co., chairman of the committee of safety and sanitation of the National Founders' Association, embodies the results of many years of experience in foundry work, and should be found of the utmost value by foundry managers in preventing distressing accidents. The general contents are listed under the following heads: Personal Caution is the Greatest Safeguard; Danger and Caution Signs; Foundry Yards; Foundry Floors; Natural Light; Artificial Light; Ventilation; Cranes, Hoisting Accessories; Rules for Cranemen; Industrial Railways; Wheelbarrows and Trucks; Foundry Ladles; Foundry Crucibles; Foundry Machinery; Grinding Machines; Tumbling Mills; Sandblasting and Other Dusty Operations; Hand Tools; Miscellaneous Safety Devices; Protective Foundry Clothing; Safety Goggles; First Aid Treatment of Injured Persons; Physical Examination of Employes. The halftone and line engravings illustrate danger points, guards, proper and improper methods of handling work, safe and unsafe equipment, etc. This is another example of specialized safety literature that should be of much value to the trade concerned.

Mechanical Drawing for Colleges and Universities. By James D. Phillips and Herbert D. Orth. 283 pages, 6 by 9 inches. 292 illustrations. Published by Scott, Foresman & Co., Chicago, Ill. Price, $1.75.

This work on drawing was prepared for use in universities and colleges, and will be followed by another suitable for high schools, the two books forming a complete course in mechanical drawing for high school and university work. The aim in the present work has been to arrange a course that shall develop the imagination and the faculty of coordination between the hand and the eye. The elements or general divisions in drawing are introduced in the order in which they would naturally come in a commercial drafting-room as follows: perspective sketching, orthographic sketching, pencil mechanical drawing, tracing and blueprinting. The importance of a working knowledge of perspective drawing is being recognized more and more as its advantages for instruction in shop work are realized, and special attention has been given to perspective and orthographic sketching. Every problem in this course requires thought on the part of the student, the aim being to develop originality. The chapter on lettering contains many plates for copy and the instructions for lettering are precise and to the point. Much importance is attached to neat and attractive work, and rightly so, as nothing injures the appearance of a drawing more than slovenly legends and dimensions.

Thomas' Register of American Manufacturers and First Hands in All Lines. 3100 pages, 9½ by 12 inches. Bound in cloth. Published by the Thomas Publishing Co., 129-135 Lafayette St., New York City. Price, $15.

This great trade directory contains an index or finding list; a list of manufacturers classified according to business; an alphabetical list of leading trade-names; and lists of architects, banks, boards of trade, chambers of commerce and similar commercial organizations, trade papers, machinists and foundries. An idea of the comprehensiveness of the work is gained from the fact that the index to the classified section covers over 140 pages, five columns to the page. The classified manufacturers list which constitutes the body of the work is the chief feature, but many users will find the alphabetical list and the list of trade-names of almost equal value. Frequently the name of the maker of a product known under a trade-name is wanted in a hurry, and this trade register generally will furnish the desired information. It is hardly necessary to point to the value of these lists to those desiring to compile mailing lists for circularizing various trades or lines of manufacture. A valuable feature of the classified manufacturers list is the approximate rating of each concern. These ratings are not intended, however, to indicate credit, but are given solely to indicate the size of the concern. The 2670 advertisements of nearly 1300 concerns of course add to the value of the work, as they often give the exact information required and save the time and trouble of writing for catalogues.

Safety Engineering Applied to Scaffolds. 354 pages, 6 by 9 inches. 127 illustrations. Published by the Travelers Insurance Co., Hartford, Conn. Price, $3.

The literature on safety engineering is becoming extensive and this latest valuable addition to the list of books specializes on a subject of great importance to builders, contractors, erectors and others having charge of work requiring the erection of scaffolding for workmen. The first section of the book discusses the reality of the scaffold hazard and the second part treats of scaffolds in a general way, outlining the subject as a whole and reviewing the various forms that are most widely used. Then follows a section on the bricklayers' pole scaffold, describing American practice and going into details under the following heads: the poles or uprights, the ledgers, the putlogs, the platform, bracing, and other safety measures. The fourth section describes the independent pole scaffold as built in American practice and the fifth section is on lashed scaffolds. Other forms of pole scaffolds are described in section six, and special safety features form the subject of section seven. General features and operations, including ladders, runways, stairways, nails, dismantling pole scaffolds are treated in section eight, and building with horses in section nine. Suspended scaffolds for construction work, under the heads of platform type of scaffold machine, overhead type of scaffold machine, features common to both types of suspended scaffolds, are dealt with in section ten; and scaffolds of other kinds, structures similar to scaffolds, and general counsel, in sections eleven, twelve and thirteen, respectively. The work is profusely illustrated with halftones and drawings. It is one of the most valuable works on safety we have seen.

The Theory of Machines. By R. F. McKay. 440 pages, 5½ by 8½ inches. 407 illustrations. Published in America by Longmans, Green & Co., New York City. Price, $4.20 net.

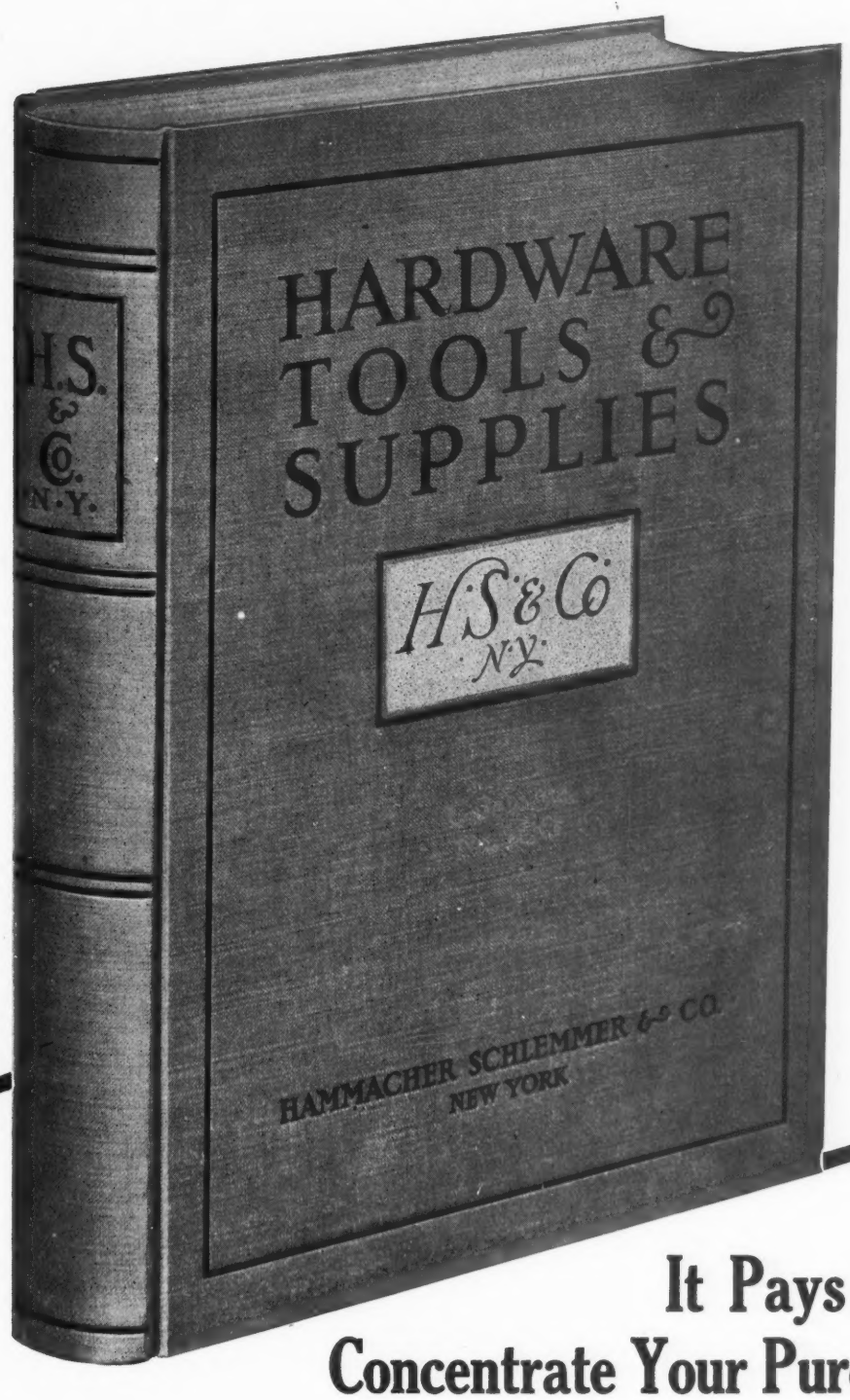
This work on mechanism and mechanical movements deals systematically with the subject, having been prepared to meet the requirements of engineering students. It treats of mechanics, kinematics of machines, and dynamics of machines under the following heads: Plane Motion of a Particle; Force and Torque; Work and Energy; Plane Motion of a Particle under Variable Acceleration—Displacement Velocity and Acceleration Diagrams; Introduction to Statics; Analysis of Motion; Synthesis of a Machine; Lower Pairing—Examples of Mechanisms obtained by Inversion; Relative Linear Velocity and Acceleration; Determination of the Angular Motion of Links; Reciprocating Motion of the Slider Crank Chain; Straight Line Motions; Higher Pairing—Toothed Gearing; General Propositions on the Forms of Wheel Teeth; Involute, Cycloidal, and Pin Teeth; Helical Gearing; Non-circular Gears; Trains of Wheels and Epicyclic Gearing; Belts and Belting; Rope and Chain Drives; Cams; Spheric Motion—Hooke's Joint; Screw Motion—Screw Gears; Friction; Static Equilibrium of Machines; Turning-Moment Diagrams; Governors; Balancing; Brakes and Dynamometers. Each chapter concludes with a list of problems that require the application of principles given in the foregoing matter for their solution. The answers to these problems are given in the back of the book. While the work is more suitable for the use of university students than machine designers, it nevertheless is one that many of the latter could use to advantage. The chapter on epicyclic gearing for example contains twenty-two pages, illustrating a number of epicyclic trains and giving methods of solving for the relative motions on each member of the trains.

Machine Design. By Albert W. Smith and Guido H. Marx. 500 pages, 6 by 9 inches. 279 illustrations. Published by John Wiley & Sons, Inc., New York City. Price, $3 net.

This work, which was published in 1905, now appears in the fourth edition. The authors have taken the opportunity to thoroughly revise the text and to include results of recent investigations of machine elements, but it is not offered as a substitute for practical experience; the authors frankly recognize the fact that the true designer must have judgment ripened by experience in constructing and operating machines. One who has experience and judgment will find in this work indispensable data, rules and formulas that he can apply and modify as the conditions seem to suggest. The contents are comprised in twenty-two chapters and an appendix under the following general heads: Motion in Mechanism; Parallel or Straight-line Motions; Cams; Energy in Machines; Proportions of Machine Parts as Dictated by Stress; Riveted Joints; Bolts and Screws; Means for Preventing Relative Rotation; Sliding Surfaces; Axles, Shafts, and Spindles; Journals, Bearings, and Lubrication; Roller- and Ball-bearings; Couplings and Clutches; Belts, Ropes, Brakes, and Chains; Flywheels and Pulleys; Toothed Wheels or Gears; Springs; Machine Supports; Machine Frames. Many illustrations of mechanical movements and machine elements are shown that to some extent have been taken from the columns of technical journals. In the selection of this material the authors were not always fortunate; an example is the Hall coupling for transmitting motion from axes at 90 degrees, at uniform angular velocity. This device is quoted from "Power," January 26, 1915, thus giving the reader the impression that it is a new and novel device. As a matter of fact, it is old, having been described in a work on mechanical movements published nearly twenty years ago as "Hobson's right-angle shaft coupling."

Ford Methods and the Ford Shops. By H. L. Arnold and F. L. Faurote. 440 pages, 7 by 10 inches. Illustrated. Published by the Engineering Magazine Co., New York City. Price, $5.

This book is based on the articles contributed to the "Engineering Magazine," by H. L. Arnold, whose death occurred in January, 1915. Mr. Faurote took up the unfinished work of Mr. Arnold and carried it through to completion. The work is unique, the authors having been afforded extraordinary privileges by the Ford management. The data covering arrangement and equipment of departments, construction and performance of special machines, detailed sub-divisions of machining and assembling operations, times and costs of jobs and finished parts, methods of cost reduction and results in practice, belong to a class of shop information seldom made public and probably never before revealed with such frankness. The fact that Henry Ford would permit intimate data of this nature to be published is an interesting sidelight on his character as a broad-minded employer and manufacturer. The contents of the book by chapter heads follow: The Genius of the Plant; The Ford Stock System and Employment Methods; How the Work is Done; Inspection and Assembly; Motor-test Blocks and Chassis-assembling Lines; Machining and Assembling the Front Axle; The Crankshaft, Piston and Piston Rings; The Commutator Production and Assembly Job; Sheet-metal Work; Conveyors, Work-slides and Roll-ways; The Bushings Job; Special Machines and Fixtures; The Foundries; How Ford Bodies are finished—Painting, Upholstering, Japanning and Baking; The New Factory Condi-



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tions; Safeguarding the Workmen. The book is one that can be studied with much profit by all concerned with the problems of manufacturing and especially those dealing with the production of motor cars and motor trucks. Production data of details are given throughout.

Shrapnel Shell Manufacture. By Douglas T. Hamilton. 296 pages, 6 by 9 inches. 172 illustrations. Published by the Industrial Press, New York City. Price, $2.50.

This book is a comprehensive treatise on the forging, machining and heat-treatment of shells, and the manufacture of cartridge cases and fuses for shrapnel used in field and mountain artillery, giving complete directions for tool equipment and methods of setting up machines, together with government specifications for this class of munition. The book has been brought out to meet the demands for a treatise dealing comprehensively with the various operations on shells, fuse parts and brass cases. In this book are included not only the unusually complete articles on shrapnel manufacture contained in the April, 1915, number of MACHINERY, but also all other material that has been published at various times in MACHINERY relating to shrapnel manufacture. In addition, there is a great deal of material obtained by the editors of MACHINERY especially for this book, and there is also a section containing abstracts of the official specifications, together with line engravings, of the details of Russian, British and American shrapnel shell bodies, fuses and cartridge cases. Hence, it is believed that this book will prove the most valuable addition to the literature of the manufacture of munitions that has been made since the beginning of the war. The chapter heads are as follows: Shrapnel Shells; Forging Shrapnel Shells; Machining and Heat-treatment of Shrapnel Shells; Machines and Tools for Shrapnel Manufacture; Making Fuse Parts; Making Shrapnel Cartridge Cases; Specifications for the Manufacture of Russian Shrapnel Shells; Specifications for the Manufacture and Inspection of Fuses for Russian Shrapnel Shells; Specifications for the Manufacture and Inspection of Russian Cartridge Cases; Specifications for British Quick-firing Shrapnel Shell; Specifications for British Combination Time and Percussion Fuses; Specifications for British Quick-firing Cartridge Case and Primer; Specifications for American Shrapnel Shells.

NEW CATALOGUES AND CIRCULARS

United Engineering & Mfg. Co., Hanover, Pa. Bulletin 20 of the Manley "Hilite" portable crane, so designed that it is not top heavy.

Cling-Surface Co., 1018 Niagara St., Buffalo, N. Y., has issued a special calendar of interest to belt users. Copies will be sent to belt users upon application as long as the supply lasts.

Ozone Pure Airifier Co., 536-538 S. Clark St., Chicago, Ill. Booklet describing ozone machines for keeping air fresh and pure in theatres, offices, stores and places where the air becomes vitiated.

Newton Machine Tool Works, Inc., Philadelphia, Pa. Catalogue 50 of Newton rotary planing machines, slotters, cold-saw cutting-off machines, vertical multiple-spindle rail drilling machines, etc.

Noble & Westbrook Mfg. Co., Hartford, Conn. Circular of marking machine designed for marking large shells, being so constructed that the shells may be rolled into the machine, marked and rolled out without requiring the operator to lift them.

Chain Belt Co., Milwaukee, Wis. Price list of standard detachable chain belt, superseding the list given in the company's general catalogue 56. The sharp advance in the cost of raw materials and labor has necessitated the fixing of higher prices.

Athol Machine Co., Athol, Mass. Circulars advertising Athol and Starrett vises, and single and double adjustable taper attachments for vises. These vises are guaranteed to be free from defects of material and workmanship, and any vise found defective will be replaced without charge.

American Blower Co., Detroit, Mich. Pamphlet entitled "The Commercial Value of Washed Air," illustrated with views of hotels, stores and other structures in which the "Sirocco" purifying and ventilating systems have been installed. Data on the capacity of air purifiers and heaters are included.

Stuebing Truck Co., 308-314 Walnut St., Cincinnati, Ohio. Pamphlet entitled "System in Trucking," describing Stuebing lifting trucks and showing their application in a variety of plants. The different models are illustrated and data covering capacity, dimensions, weight, etc. are given.

Diamond Power Specialty Co., Detroit, Mich. Circular describing "insuluminum" used in the construction of the "Diamond" soot blower. The process by which insuluminum is produced was originally called "calorizing." By it, aluminum is deposited on steel (or other metals), forming an alloy that is highly resistant to the action of heat.

Speed Controller Co., Inc., 257-259 William St., New York City. Circular of the "Speedco" automatic precision governors for regulating the power and speed of machinery. The construction of the apparatus is illustrated and described, and data on the sensitiveness of the double-acting controller, as applied to electric motor control through field rheostat, are included.

Deane Steam Pump Co., 115 Broadway, New York City. Bulletin D 184 on high-pressure hydraulic power pumps, illustrating vertical and horizontal pumps of standard types, and giving partial lists of sizes. Automatic by-pass and check valves for high-pressure hydraulic pumps are also described, these valves being made as independent units, so they may be readily replaced in case of damage.

Gleason Works, Rochester, N. Y. Booklet entitled "Spiral Type Bevel Gears," giving a clear and concise description of this type of gearing, together with such information as is required by designers and users of these gears. The booklet relates to the advantages, strength and wear, efficiency, applications, angle of spiral, direction of spiral, thrust, and the machining of the blanks for spiral type bevel gears.

J. E. Snyder & Son, Worcester, Mass. Catalogue of vertical drilling and tapping machines, illustrating twenty-three patterns, ranging in size from a 21-inch sliding-head high-speed drilling machine to a 46-inch sliding-head friction back-geared machine. J. E. Snyder & Son is the only concern in the United States that has specialized exclusively on vertical drilling and tapping machines for the past thirty years.

Standard Electric Tool Co., Cincinnati, Ohio. Bulletin G-9 on "Standard" high-power portable electric ball bearing grinders. Bulletin D-11 on "Standard" high-power direct-current portable electric drills. Bulletin D A-11 on "Standard" high-power two- and three-phase alternating-current portable electric drills. Bulletin U-11 on "Standard" high-power universal portable electric drills, operating on direct current and single-phase alternating current, sixty cycles or less.

National Tube Co., Frick Bldg., Pittsburg, Pa. Colored circular illustrating the relative merits of the grand prize, the medal of honor, gold medal, silver medal and the bronze medal conferred by the jury of awards at the Panama-Pacific International Exposition. The artist has depicted a mountain scene in which the grand prize is represented by a snow-capped peak overshadowing the lesser peaks representing the inferior medals. The National Tube Co. was awarded the grand prize, and its advertising department has adopted this method of illustrating what the grand prize means. It puts the "National" pipe and allied products in a position of "overshadowing supremacy."

New Departure Mfg. Co., Bristol, Conn. Pamphlet entitled "Ball Bearings in Commercial Applications," illustrating a great variety of applications of "New Departure" bearings, including motor cars, motor trucks, agricultural tractors, industrial tractors, electric and gasoline motors, motor-driven fire apparatus, etc. The ball bearing is referred to as the "conqueror of friction." The great strength of steel balls is described, and apparatus for testing steel balls up to 2½ inches in diameter is illustrated. The large number of illustrations of apparatus to which ball bearings have been successfully applied shows how widespread is the movement for eliminating useless friction and waste work. The New Departure Mfg. Co. in publishing this pamphlet feels that it is doing an educational work, and that the pamphlet is in no sense a catalogue. The object is to educate the great mechanical public in the use of ball bearings and to overcome the prejudices of mechanical engineers in general.

TRADE NOTES

Rub-On Mfg. Co., Inc., 87-97 Brayton St., Buffalo, N. Y., is now manufacturing and selling the "Crone" valve dressing and reseating tool.

Aberthaw Construction Co., Boston, Mass., has removed its office to more commodious quarters in the newly erected Niles building, 27 School St.

Defiance Packless Valve Co., 891 Rand-McNally Bldg., Chicago, Ill., has been reorganized. J. W. Flower of the Rose-Stephans Co., has joined the concern.

Midvale Steel Co., Nicetown, Philadelphia, Pa., and Worth Bros. Co., Coatesville, Pa., have taken the sixteenth floor of the Widener building, Chestnut St., Philadelphia, Pa., for their general offices.

American Swiss File & Tool Co., 24 John St., New York City, was awarded a medal of honor, the highest, by the superior jury of awards, at the Panama-Pacific International Exposition, for its exhibits of "American-Swiss" files.

Federal Machinery Sales Co., 12 N. Jefferson St., Chicago, Ill., has opened a store and warehouse where it will carry a line of new and used machine tools. The officers are: James L. Gough, president; J. B. Doan, vice-president; Charles T. Bush, treasurer; and Charles A. Odegaard, secretary.

La Salle Machine & Tool Co., LaSalle, Ill., has added to its line of machine tools by purchasing the manufacturing rights in the "American" twist drill grinders from the Heald Machine Co., Worcester, Mass., whereby it has taken over all patents, drawings, patterns, parts in stock and good will of this line.

American Tool Works Co., Cincinnati, Ohio, is preparing for the construction of a new plant on the block bounded by Pearl, Eggleston, Third and Butler Sts. The building will be of reinforced concrete, 256 feet front by 260 feet deep, four stories and basement, and will afford 238,000 square feet of floor space.

Reliance Engineering Co., Lansing Mich., has succeeded the Seager Engine Works, builders of the "Olds" stationary and portable gas, gasoline and kerosene engines, hoists, pumping outfits, etc. The officers of the Reliance Engineering Co. are: C. P. Downey, president; F. L. Smith, vice-president; E. C. Shields, secretary; and J. W. Wilford, treasurer and manager.

Whitney Mfg. Co., Hartford, Conn., announces that, owing to the changed conditions with regard to labor, materials, machinery, etc., it has withdrawn all prices and quotations on chains, sprockets, and milling machines, Woodruff keys and cutters. During the next few months customers will be requested to submit estimates of their requirements, and quotations will be made for each individual case.

Hyatt Roller Bearing Co., Newark, N. J., announces that J. D. Mooney, sales manager, has put O. W. Crawshaw in charge of the sale of Hyatt lineshaft bearings. Mr. Crawshaw was formerly with one of the largest power transmission houses in Chicago, and is well acquainted with the mill supply business throughout the country. He will give his entire time to the work of the new division, giving closer attention to dealers handling the Hyatt line than has heretofore been possible.

New Process Gear Corporation, Syracuse, N. Y., has nearly completed the improvements in the building formerly used by the Monarch Typewriter Co., which has been acquired by the corporation, and the machinery is being installed. The five-story, reinforced concrete building that is being erected for the general manufacturing and heat-treating use is well under way. This building is 180 by 100 feet. The two buildings when completed will give the corporation greatly increased floor space and manufacturing capacity.

Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill., was awarded the grand prize for toolholders at the Panama-Pacific Exposition at San Francisco, Cal., this being the first grand prize ever awarded for an exhibit of tool-holders at any international exposition and the only grand prize awarded exclusively and specifically to an exhibit of tool-holders independently of other products. The company was also awarded a medal of honor for its other Armstrong products exhibited, including ratchets, drop-forged wrenches, clamps, lathe dogs, etc.

O'Brien Machinery Co., 107 N. 3rd St., Philadelphia, Pa., is a new concern, organized for selling steam and electrical equipment, machine shop equipment, power transmissions, wood-working machinery and supplies of all kinds. The company is composed of Clarence J. O'Brien and Frank L. O'Brien, formerly with Frank Toomey, Inc. The concern has a warehouse and an organization equipped to store and overhaul all machinery before shipment. Catalogues, price lists and jobbers' discounts from the manufacturers whose products will be sold, are solicited.

Buffalo Foundry & Machine Co., Buffalo, N. Y., builder of "Buffovak" vacuum apparatus, including vacuum dryers of all types for drying all sorts of materials; dry vacuum pumps; condensers; vacuum drying and impregnating apparatus; "Buffokast" chemical apparatus, including complete plants and apparatus for the manufacture of aniline, phenol, beta, naphthol, picric acid, caustic soda, acids, chemicals, and kindred organic materials; and "Bell" steam hammers; has opened a New York office at 1432 Whitehall Bldg., 17 Battery Place. The company also does a general jobbing foundry and machine business, and is prepared to quote on castings up to 200 tons in weight each, including the necessary patterns and machine work.

Reed-Prentice Co., Worcester, Mass., has changed ownership in its common stock. The entire common stock, the par value of which is $750,000, has been sold to a group of Boston investors, headed by Robert F. Herrick. The original issue of $1,250,000 common stock was cut down about a year ago to $750,000, which reduced the capital stock of the company from $2,500,000 to $2,000,000. The new officers of the corporation are: Robert F. Herrick, president; Albert E. Newton, vice-president and general manager; Jeremiah J. Mackin, clerk and treasurer; Charles M. Thayer, general counsel. The board of directors consists of Robert F. Herrick, Malcolm Donald, Robert C. Morse, Henry P. Kendall, George C. Lee, Frank A. Drury, Homer Gage and Albert E. Newton. The company has unfilled orders amounting to about $3,000,000.

Electric Steel Co., Chicago, Ill., has been organized by men prominent in the Link-Belt Co. for the manufacture of small castings, and especially small castings in alloy steels. The officers are: Charles Piez, president; P. L. Cooney, secretary and treasurer; John M. Olmsted, vice-president. Mr. Piez is president of the Link-Belt Co., Mr. Cooney is vice-president and Mr. Olmsted for some years has been a member of the sales force of the Link-Belt Co. These three, with W. C. Frye and C. R. Messinger of Milwaukee, constitute the board of directors. Mr. Frye is the financial head of the Sivyer Steel Casting Co., the Federal Malleable Co. and other corporations of Milwaukee; while Mr. Messinger is vice-president of the Sivyer Steel Casting Co. In order to start production at once the company has leased the plant at 31st and Wood Sts., formerly occupied by the Wildman Boiler Works.

Peter A. Frasse & Co., Inc., 417-421 Canal St., New York City, importers and manufacturers' agents of tubing, steel, tools, and supplies, has purchased a tract of land, 65 by 344 feet, close by the tracks of the Central New England Ry. in Hartford, Conn., on which a new mill and warehouse will be erected. Hartford was chosen as the location for the new mill and warehouse, as it is considered the best point from which to serve the trade of Western New England, and is also in direct communication with Pittsburg and within easy reach of the company's warehouses in New York, Buffalo and Philadelphia. The building will be three stories high and of either mill or concrete construction. In the heat-treating department, furnaces for annealing, heat-treating, casehardening and tempering all steels will be provided. Draw-benches for cold-drawing will be installed and lathes for machining steel bars, etc. The equipment will enable the company to deliver at short notice anything that a manufacturer might need in the way of raw material as well as semi-finished material in the various grades of steel of its manufacture.